SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau)

1920-21

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SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1921

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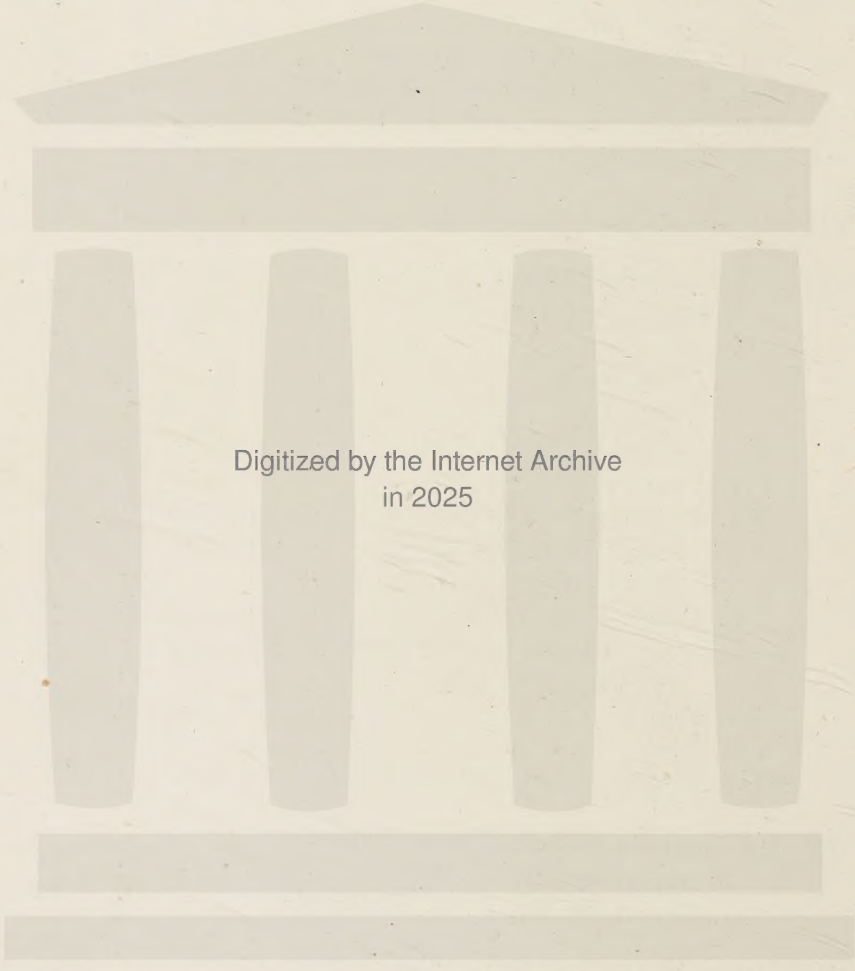

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Scientific Reports of the Agricultural Research Institute, Pusa

(*Including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau*)

1920-21

REPORT OF THE DIRECTOR.

(S. Milligan, M.A., B.Sc., and G. S. Henderson, N.D.A., N.D.D.)

I. Charge and Staff.

Charge. Mr. S. Milligan held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, throughout the year.

During the absence of Mr. G. S. Henderson on deputation to England, the post of Joint Director of the Institute was held by Mr. W. McRae from 22nd September, 1920, to 4th January, 1921, and by Mr. T. Bainbrigge Fletcher from 5th January to 28th February, 1921.

Staff. Mr. M. Wynne Sayer, Supernumerary Agriculturist, officiated as Imperial Agriculturist during Mr. Henderson's absence on deputation to England.

Dr. J. Sen was relieved of the duties of the Imperial Agricultural Chemist by Mr. F. J. Warth on 21st January, 1921.

On the expiry of the leave granted to Mr. A. Howard, C.I.E., he resumed charge of the duties of Imperial Economic Botanist, relieving Mr. G. P. Hector on the 26th October, 1920. Mrs. Gabrielle L. C. Howard, Second

Imperial Economic Botanist, returned from leave on the same date.

Mr. W. McRae, Imperial Mycologist, proceeded on leave on 5th January, 1921, Dr. F. J. F. Shaw acting as Imperial Mycologist.

Mr. J. F. Dastur, Supernumerary Mycologist, returned to Pusa on 13th December, 1920, on the expiry of his deputation period to England, and has been appointed to act as Second Imperial Mycologist.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist, has held charge of the Pathological Entomological Section from 21st August, 1920.

During Mr. N. V. Joshi's absence on leave from 1st April to 1st June, 1921, Mr. K. S. Viswanatham officiated as Assistant Agricultural Bacteriologist.

Major W. R. G. Atkins, who was appointed Indigo Research Botanist from 2nd October, 1920, resigned the post after two months' service.

II. Work of the Institute.

Scientific Work. The more important work of the Institute is briefly summarized below :—

Botanical Section. The systematic replacement of the country wheats by Pusa 12 and Pusa 4 by starting new centres of seed distribution and restocking old ones, in co-operation with provincial officers, forms one of the main features of the work of this Section. At the same time the search for still better varieties continues, and the trials of some strains obtained by crossing Pusa 6 with a strong strawed, heavy yielding parent were advanced a stage during the year. Considerable progress was made in the isolation and study of the unit species which make up the Indian linseed crop. A Bulletin is being issued dealing with the commercial possibilities of safflower oil. Tobacco and gram are other important crops, selected varieties of which are being distributed from Pusa. Amongst important physiological problems under investigation by this Section the chief are the determination of the factors

involved in the observed deleterious action of grass on fruit trees, the influence on growth of various factors involved in poor soil aeration, and the conditions of the root system and of the soil which appear to precede infection by fungi and attack by insects.

Chemical Section. The investigations into the methods of analysis for determination of organic nitrogen, nitric nitrogen and phosphoric acid, referred to in last year's report, were completed during the year, and the results reported to the Second Meeting of Chemists held at Pusa. The study of the sugarcane enzymes and the conditions under which favourable results from "windrowing" may be obtained was continued. "Windrowing" was tested both under field conditions prevailing at Pusa and under regulated laboratory conditions, the windrowed cane being found to be decidedly superior to the cane left uncut. The determination of carbon dioxide on grassed and cultivated land was continued.

Bacteriological Section. Investigations into the losses of nitrogen from cattle dung and urine during storage under aerobic and anaerobic conditions were continued. The solubilisation of rock phosphate by composting with cake or green manure and the nitrification of *mahua* cake (*B. latifolia*)—both problems of great practical importance —are also being studied. The use of pure culture of bacteria for the improvement of the process of indigo manufacture gave promising results during the season under report. Inoculation of retting water previously sterilized with the laboratory prepared "E. C.", with a pure culture of indican hydrolyzer, gave produce of the remarkably high quality of 78·5 per cent. which is probably the highest ever obtained in Bihar. The "E. C." sterilizer has been found useful in many directions, not the least in the treatment of septic wounds.

Mycological Section. This Section was again short-handed during the year as regards higher staff. The study of the genus *Helminthosporium* on cereals and sugarcane was continued. Appreciable progress was made with investigations into diseases of paddy caused by *Piricularia*,

the immunity of thick canes to smut disease, and diseases affecting jute and areca palms.

Entomological Section. The investigation of borers in sugarcane and other gramineous plants was continued and given a large share of attention. Observations made confirmed previous experience that thin varieties of cane show a greater immunity from borer attacks than do thick ones and that the percentage of attack generally and gradually decreases with the growth of canes. Amongst other items of interest, a bad attack of Aphids on an experimental crop of wheat was checked in a few days by the liberation in the field of large numbers of Coccinnellid beetles collected from other wheat areas on the farm, and an attack of Red Spider on jute was controlled by spraying with crude oil emulsion and sulphur. The work under the pathological section was continued mainly with reference to the transmission of surra amongst camels and the role of blood in ovulation in Culicidæ. Work on useful insects such as bees, lac-larvæ and silkworms was continued.

Protozoological Section. Last year's work was continued with a view to winding up the investigations at an early date. Laboratory results were confirmed by a local census of the incidence of silkworm diseases in the Bengal villages, and reinfection experiments in the houses of the silkworm rearers were carried out. The latter investigation confirmed the view that the supply of good seed to rearers is all important.

Agricultural Section. The permanent experiments are being continued in collaboration with other Sections of the Institute. While the general results of selective breeding of the Montgomery herd of cattle are satisfactory, it will not be until next year that the second generation resulting from the scheme laid down in 1913 will be under test for milk. The various second generations of the Ayrshire-Montgomery cross are also expected to be in milk next year. Until then it is of course impossible to indicate along what lines further breeding will proceed. The first real comparative tests of the cost of deep ploughing by steam winding tackle and tractors resulted in favour of the former.

Imperial Dairy Expert. From the large number of requests for help and advice regarding building plans, live stock, machinery specifications, etc., it is evident that the establishment of this Section has created general interest in dairying matters in India. There is, however, great need for men trained in up-to-date methods. Two dairy schools for the training of such men have already been sanctioned by the Secretary of State, and it is hoped that at least one of them will shortly materialize.

Sugar Bureau. During the year, the Bureau, owing to the sittings of the Indian Sugar Committee, was mainly engaged in furnishing statistical and other information required by that body. Assistance was given to prospective purchasers of sugar machinery by placing them in touch with manufacturers and arranging for early delivery of the machinery required. The Bureau has also undertaken the publication, for the benefit of sugar firms in India, statistical notes bearing on the production and consumption of sugar in different parts of the world and the fluctuations in the world's price of sugar.

The work of the *Indigo Section*, which is on a temporary basis, is published in a special series of Indigo Publications. A separate annual report has, therefore, not been considered necessary.

Training. Eleven post-graduate students were under training at the Institute during the year in the following subjects :—

General Agriculture	3
Agricultural Chemistry	1
Mycology	3
Economic Entomology	2
Agricultural Bacteriology	2

In addition, Mr. P. V. Casling, I.M.D., attended the Entomological Laboratory for two months for a short course with especial reference to the study of Diptera of sanitary importance.

Short-courses in lac-culture and sericulture were taken by five and seven students respectively, while instruction

in sericulture not amounting to a regular course was given to six others.

III. Publications.

Twenty-seven Memoirs, six Bulletins and two Indigo Publications were issued during the year, while over 40 publications were in the press on 30th June, 1921.

"The Agricultural Journal of India" continues to gain in popularity, especially among the zemindar classes, and it became necessary during the year to increase the print order by 250 copies.

IV. Accounts.

The total expenditure during the financial year ending 31st March, 1921, was Rs. 9,84,553 as against Rs. 6,59,343 during the previous year, an increase of Rs. 3,25,210 debitable mainly to capital expenditure for which a grant of Rs. 2,52,000 was sanctioned out of the imperial grant of 15 lakhs for agricultural education.

	Rs.
General expenditure of the Institute (including Office of the Agricultural Adviser and Director)	3,38,044
Chemical Section	60,262
Mycological Section	62,267
Entomological Section	69,632
Pathological Entomological Section	29,233
Bacteriological Section	54,111
Botanical Section	45,205
Agricultural Section	2,44,307
Indigo Research Section	50,827
Protozoological Section	25,268
Physiological Chemical Section	5,397
Total	9,84,553

A sum of Rs. 15,000 was paid as grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricul-

tural Adviser to the Government of India for special agricultural experiments were as follows :—

	Rs.
Apparatus for the Chemical Section . . .	1,690
Kinematograph, agricultural demonstration . .	350
Materials for fitting up a new laboratory for the Imperial Agricultural Chemist	1,812
Removal of pumping engine	979
Experimental cotton cultivation by the Imperial Cotton Specialist, Poona	1,000
Mosquito experiments	469
Pay of a surveyor	214

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 30,313 as against Rs. 36,221 last year.

V. Conferences.

The Biennial Meetings of Entomologists, Mycologists, and Agricultural Chemists and Bacteriologists were held in February 1921. As on the previous occasion, the meetings were not confined to members of the Agricultural Department, and were largely attended by scientific workers attached to other official and semi-official institutions. The Proceedings of the Chemical and Mycological Meetings have already appeared; those of the Entomological Meeting which are more detailed are still in the press.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and G. L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist was in charge of the Section during the year under review from October 26th, 1920, till June 30th, 1921. Previous to this, Mr. G. P. Hector officiated during which period the staff was mainly occupied in carrying out certain investigations on jute, rice and *rahar* (*Cajanus indicus* L.) for this officer. As this work forms part of the investigations in progress at Dacca, the results will be dealt with elsewhere. The work of the staff continues to be satisfactory, in particular that of Maulvi Abdur Rahman Khan, Babu Kashi Ram and Sarup Singh.

While on leave, a paper on *The improvement of crop production in India* was read before the Royal Society of Arts on May 30th, 1920. For this paper the medal of the Society was awarded.

II. Wheat.

Seed distribution. The demand for botanically pure seed of the Pusa wheats for trial in various parts of India including the Indian States, for starting new centres of seed distribution and for restocking old ones continues. As far as possible, these requests are dealt with at Pusa but when large quantities of seed are asked for, it is often necessary to invoke the good offices of members of the Provincial Agricultural Departments who regularly store large quantities of pure seed of these varieties. Mr. B. C. Burt, Mr. G. Clarke and Rai Bahadur L. C. Sharma in the United Provinces have frequently rendered valuable assistance in this respect. During the year under report, 184

maunds of selected seed, mostly Pusa 12 and Pusa 4, was distributed from the Botanical Area to 52 applicants. In addition, a large number of small samples were despatched through the post to various correspondents in India and other countries. Some of the Pusa wheats are being found useful in breeding. Thus Professor E. Schribaux, of the Institut National Agronomique, Paris, writes (letter dated Paris, June 1st, 1921) :—" Les renseignements que vous me donnez sur la résistance à la rouille, sont d'un intérêt très grand. De mon côté, j'ai obtenu, en croisant Pusa 4 avec Bordeaux, des hybrides chez lesquels cette résistance s'est nettement manifestée."

A beginning was made during the present year in recording the progress made in the systematic replacement of the country wheats by Pusa 12 and Pusa 4. The first area selected was the Central Circle of the United Provinces and the present position of the work has been summed up in Pusa Bulletin 122 in the preparation of which Mr. B. C. Burt, the Deputy Director of Agriculture of the Circle, collaborated. In this way, it has been possible to express in concrete form not only the aims and objects of the work and the progress made but also to deal with the various unofficial methods of seed distribution which have been tried by the Agricultural Department. The problem to be solved was the establishment of a new variety of wheat of higher yielding power and distinctly better grain quality than the local and the enlistment of the active support of the people in the undertaking.

The general principles underlying the methods of seed distribution to be adopted in the Central Circle were carefully considered before the work was begun. It was decided to aim at the complete replacement of the country wheats of the alluvium by Pusa 12 and of the Bundelkhand canals by Pusa 4 and to base the various distribution schemes on the central seed farm at Kalianpur. At this centre, large stocks of botanically pure seed are raised every year which are available for starting new local cen-

tres of distribution and for restocking old ones. This supply was supplemented at first by large consignments grown for the purpose on some of the indigo estates in Bihar, on the cotton seed farm at Kalai near Aligarh and on the Sugar Experiment Station at Shahjahanpur. In recent years, a large quantity has been obtained in the Circle itself from the numerous private seed farms which have arisen. All seed purchased locally is inspected in the field and care is taken to prevent admixture on the threshing floors. To keep a further check on the purity, samples are always grown on on the Cawnpore farm and the percentage of impurity recorded. The percentage of admixture has proved to be exceedingly small.

Given an adequate supply of pure seed and a trained staff for employment in the Districts, the next point to determine was the principle of distribution to be adopted. Should the seed be given out to as many cultivators as possible or should it be concentrated? After the preliminary distribution for the purpose of testing the suitability of the variety, the principle of concentration rather than diffusion has been adopted. The policy in force is to aim at the complete replacement of the country crop taking the village as a unit. Many advantages have been found to result from this method. Large tracts of one variety rapidly arise which soon influence local markets and assist in building up the reputation of these wheats for food purposes and in establishing the premium. Admixture with other kinds is rendered more difficult and the danger of natural crossing is considerably lessened. These continuous areas increase the supplies of pure seed available to the Agricultural Department and also have an effect, by virtue of their size, on the natural expansion of the variety.

Having decided on the general policy underlying the distribution, all possible local agencies had to be tested by means of which the Agricultural Department could extend its activities *without unduly expanding its staff and the size of its seed farms.* The Department could not possibly

grow more than a small fraction of the seed required for sowing every year. The more the staff working in the Districts is expanded the greater the time spent in supervision and the more unwieldy the organization becomes. It was clear that if seed distribution was to be a success the co-operation of the people must be obtained and all existing agencies utilized to the full.

While the Co-operative movement has, through the primary societies and the central banks, been of considerable use in this work, a modified organization—the agricultural supply society—has had to be evolved for dealing adequately with the seed supply. One such society, started in 1920 in Hardoi, has already dealt with over 3,000 maunds of Pusa 12 seed.

In the introduction of Pusa 4 on the Bundelkhand canals, the Irrigation Department has done valuable work. The effort of the Irrigation officers has been greatly assisted by the policy of the United Provinces Government which permits *taqavi* under the Agricultural Loans Act for the purchase of improved seed. This is provided by the Agricultural Department while the numerous applications for loans and much of the actual distribution of seed are dealt with by the Irrigation Department. This arrangement ensures the placing of seed in those villages where canal water is available.

Some of the Court of Wards' Estates in the Central Circle have been of great value in the distribution of seed. The Katesar Estate in Sitapur, managed by Mr. W. C. G. Dunne, M. B. E., possesses its own seed farm of 200 acres and its own seed store capable of dealing with 4,000 maunds of seed every year. Several other estates are doing similar work.

The most significant and promising development in the distribution of Pusa 12 in the Central Circle is the rapid increase in the number of private seed farms managed by the zemindars themselves. At the present time, sixty of these private farms, from 10 to 250 acres in area, are work-

ing in co-operation with the Agricultural Department. A much larger number of areas of *sir* land growing these wheats, which cannot be described as farms, also exist. The total area is very great and every year produces thousands of maunds of seed. In some cases, a portion of the seed is purchased by the Agricultural Department for its own operations but the bulk is distributed by the zemindars among their own tenants.

Side by side with these various seed distributing agencies, the staff of the Agricultural Department is constantly engaged in introducing improved seed by means of village demonstrations. In 1920, the number of villages dealt with in the Central Circle was 915 and the area 18,062 acres. The amount of seed issued in 1919 from stores controlled by the Department was 31,000 maunds.

The importance of standing power. The importance of strength of straw in wheat cultivation is well brought out in some wheat trials carried out at Gorakhpur by Mr. W. N. Harvey (Plate I). Plots of Pusa 4 and the local wheat, 0·24 acres in area, were sown in triplicate and the wheat was irrigated once. In spite of rain and wind in January which laid the local variety, Pusa 4 stood well till harvest and gave a yield of $29\frac{1}{2}$ maunds of seed to the acre. As intensive cultivation increases and as the practice of growing wheat on the manurial residues after sugarcane spreads, standing power will become an important factor in the choice of varieties. The sparse foliage of Pusa 4 combined with the natural strength of its straw and its short growing period combine to make it a suitable variety for essays in intensive cultivation. A crop of as much as $40\frac{3}{4}$ maunds of grain to the acre has already been obtained on the large scale at Mangalghar in Bihar under estate conditions.

The extension of the wheat area. One of the limiting factors in the growth of wheat in India is soil-temperature. This imposes a definite period during which the crop must ripen. The seedlings are destroyed by white ants if the

Pusa 4.

Gorakhpur red.

THE IMPORTANCE OF STANDING-POWER IN INTENSIVE WHEAT CULTIVATION.

PLATE I.

soil is too hot at sowing time while the advent of the hot weather in the spring checks ripening and the crop withers. Varieties which mature with great rapidity and which require a short growing period can, however, be matured in tracts where the cold season is too short for the ordinary crop. Such a case is reported by Mr. S. K. Basu, Deputy Director of Agriculture in Orissa, who recently raised a crop of Pusa 4 of over 18 maunds to the acre on the rice areas in Orissa in which the paddy crops had been destroyed by the high floods of July of last year. The wheat was sown in the first week of November and harvested early in March. The trials are being extended with a view of introducing the wheat crop in a tract in which up to the present it does not appear to have been cultivated.

Water saving in wheat cultivation. In view of the attention now being paid to water saving in wheat growing and to the necessity of obtaining the highest duty of water in North West India, the results obtained in this subject, which were originally published in *Quetta Bulletin* No. 4, have been reprinted as Bulletin 118 of this Institute.

Trials of the new Pusa wheats. The trials of some of the new wheats obtained by crossing Pusa 6 with a strong strawed heavy yielding parent were advanced a stage during the year. As the land at Pusa is not even enough for such purposes, the tests were carried out by Mr. B. C. Burt on the Kalianpur farm using Pusa 12 as the standard, the trials being repeated four times. The results in maunds per acre are given in the following table :—

Trials of Pusa wheats at Kalianpur, 1920-21.

	A		B		C		D		Average	
	m.	s.	m.	s.	m.	s.	m.	s.	m.	s.
Pusa 12 . .	32	8	33	4	35	10	32	10	33	8
Pusa 50 . .	30	18	28	21	30	15	32	30	30	21
Pusa 51 . .	30	6	31	1	33	5	31	0	31	13

	A		B		C		D		Average	
Pusa 52 . .	28	9	30	6	29	30	28	0	29	1
Pusa 53 . .	28	9	28	33	28	35	26	0	27	93
Pusa 54 . .	32	2	32	14	34	20	32	20	32	34

One of the objects of this work is to obtain a bearded wheat with strong straw which will yield as well as Pusa 12 under cultivators' conditions. Pusa 54 and other types not yet tested at Kalianpur appear promising for this purpose. In some parts of India where the crop is damaged by wild animals and birds during the ripening period, the cultivators are very anxious to obtain an improved bearded wheat.

III. Other Crops.

Tobacco. The demand for seed of Type 28, which from 1916 to 1920 remained fairly steady at about 12,000 acres a year, suddenly increased more than fourfold during 1921 when seed sufficient for about 50,000 acres was asked for and supplied. The increased demand came from the Indian Leaf Tobacco Development Company who have been distributing this seed to the cultivators in Bihar for some years. Recently, successful trials of Type 28 have been made by this Company at Guntur in the Kistna delta where a local demand for seed is already springing up. Mr. Acree reports as follows on the Guntur trials (letter dated Dalsing Serai, April 23rd, 1921):—

"Last year we experimented with Pusa 28 seed on our farm near Guntur and the experiment turned out very successfully. In our experiments we found the Pusa 28 tobacco seed germinated exceedingly well and about 97 per cent. of the plants lived when transplanted. They produced a tobacco of very good colour which will be useful in the manufacture of cigarettes." The Indian Leaf

Tobacco Development Company are also undertaking trials of this variety in British East Africa, Kenya and Zanzibar. After providing for 50,000 acres this year, sufficient seed for 60,000 acres has been carried over for 1922 but the advance indents have already reached this figure.

Fibre plants. A successful trial of the improved variety of *patwa* (*Hibiscus cannabinus* L.) known as Type 3 is reported by the South African Jute Company, Barberton, South Africa, where six acres were grown. The plants withstood drought and produced straight, unbranched stems from 10 to 14 feet in height and a yield of fibre of 35 maunds to the acre on land freshly broken. It is expected that with the soil in better condition the yield will be increased. The trials are being continued on a larger scale. Although this type does very well in many parts of India, the difficulty of obtaining pure seed in bulk militates against its spread. The Botanical Area at Pusa is too small to grow the quantity required while the difficulties involved in preventing natural crossing are not easily overcome on the ordinary Government farms. As, however, these difficulties may be solved in the future, Type 3 is being grown on at Pusa and a small supply of pure seed is being maintained.

The breeding work on Roselle (*Hibiscus Sabdariffa* L.), which was discontinued in 1919 and 1920 on account of our absence on leave, has been resumed.

Oil seeds. Considerable progress was made in the isolation and study of the unit species which make up the Indian linseed crop of commerce. It is hoped to publish the results during the ensuing cold weather when the types will be repeated for the detailed verification of the classification. The testing of some of the unit species has commenced and is yielding promising results.

A bulletin has been prepared and is now in the press dealing with the commercial possibilities of safflower oil and with the result of an exhaustive examination of this product in Great Britain. The work was carried out by Mr. S. Stewart Remington (at his laboratory at Aynsome,

Grange-over-Sands, Lancashire) who summed up his report as follows :—

"From the foregoing details it will be seen that safflower seed oil should become a very valuable economic product if it can only be brought over and utilized on the Home markets. It should be an excellent oil, if properly manipulated, for the colour, paint, and varnish industries, also for soap and linoleum manufacture, as well as for edible and culinary purposes, in the latter cases if proper means are devised as regards refining and bleaching. The investigations so far undertaken on safflower seed and safflower seed oil by no means exhaust the subject. As regards the seeds, further investigations are desirable, and are being continued at these laboratories on the proteins of safflower seed, and will be referred to later. A further investigation is also desirable as regards the changes taking place in the oil under ozonisation which can be advantageously carried out at the laboratories as well as more extended tests than have at present been possible on the weathering of paints and varnishes made with this oil, in conjunction with various combinations of dryers, especially as regards varnishes and the quick maturing of the same. These it is hoped will form the subject of future papers on this interesting Indian product."

Gram. Some progress was made in the testing of a number of promising types of gram and 43 maunds of selected seed was distributed for this purpose. At the Raya farm near Muttra, large scale trials of Pusa 17 and Pusa 18 gave 21 and 22 maunds of grain to the acre respectively. The trials, however, were interfered with by premature hot winds when the plants were in flower.

Indigo. With the publication of the memoir on the wilt disease of indigo, the working out of a suitable method of selection and the discovery of an improved method of seed growing, the original programme of work on this crop came to an end in 1919. As the subject does not present for solution any further problems of a general

character, we do not propose to prosecute any further investigations on the natural indigo industry. Our views on the impracticability of the improvement of Java indigo by chemical selection have been confirmed by an independent examination of the question carried out by Dr. W. R. G. Atkins, O.B.E., who held the special post of Indigo Botanist for a few weeks in 1920. Dr. Atkins has published his views on this question in the issue of *Science Progress* of July, 1921.

One interesting observation on the growth of Java indigo was made during the year which is worthy of record. In 1919, indigo was sown in an uncemented lysimeter with free drainage and splendid crops were obtained and no trace of wilt was observed. The stumps were left in the soil and two cuts were obtained the following monsoon (1920) after which a change took place in the physical condition of the soil, drainage became impossible and the plants died. In October 1920, the soil was removed from the lysimeter and at once replaced. Java indigo seed was sown the same day and up to the time of writing two fine healthy cuts have been obtained and the stumps are shooting again. This result appears to be directly opposed to the theory of phosphatic depletion which has been advocated to account for the well-known difficulties in the growth of indigo in Bihar soils. We have here a case where Java indigo has been grown for leaf for three years in succession in a comparatively small volume of Pusa soil without any falling off in vigour.

IV. Physiological Investigations.

For some years, increasing attention has been paid to the physiological aspects of crop production and some of the results on soil aeration and root development have already been published. A number of other isolated results, however, have not yet reached the stage at which they can usefully be printed. Some of these have been investigated further during the year and it is proposed in

the future to devote as much time as possible to these and similar questions. One of the physiological problems now under investigation is the determination of the factors involved in the observed deleterious action of grass on fruit trees at Pusa. A mass of results on this question has been obtained during the year which it is hoped to publish shortly. Mr. Jatindra Nath Mukerjee, First Assistant to the Imperial Agricultural Chemist, is collaborating on this subject as far as the periodical examination of the soil gases is concerned. Another subject under examination is the influence on growth of the various factors involved in poor soil aeration. In this question, the modified method of pot culture described some years ago as well as the various types of lysimeters in use in the Botanical Area are proving of great use in supplementing the laboratory work.

A result likely to prove of practical value has recently emerged from these investigations. One of the difficulties in the growth of lucerne under North Bihar conditions is to preserve the crop during the rains and also to reduce the volume of irrigation water needed during the rest of the year. During the monsoon, lucerne ordinarily dies out from wilt as a result of poor soil aeration following the consolidation of the surface soil. During the rains of 1920 (a year of short rainfall) and in the present year up to the end of August, it has been possible to preserve the lucerne crop and to carry it on successfully for two seasons by growing it on flat beds three feet wide with irrigation furrows one foot wide between the beds (Plate II). These latter act as local drains during the rains and improve the soil aeration to such an extent that the stand survives. The method is now being applied to the growth for seed of crops like *sanai*, *patwa* and Java indigo which often set seed with great difficulty due to poor soil aeration during the late monsoon. Possibly the method may also prove useful in the growth of jute seed in Bengal where similar difficulties obtain.

During the progress of our plant breeding and other investigations, a number of observations have accumulated

AN IMPROVED METHOD OF LUCERNE CULTIVATION IN BIHAR.

PLATE II.

on the physiological aspects of disease resistance and on the conditions of the root system and of the soil which appear to precede infection by insects and fungi. The transition between health and disease in crops appears to be much longer than is usually supposed and seems to depend on the condition of the absorbing root system. Plants in good health appear to be immune to the attacks of parasites. In order to assist in stimulating young investigators to take up these matters in more detail, our observations were brought together in a paper read at a meeting of the Association of Economic Biologists at Kew in September 1920 and published in full in the *Annals of Applied Biology* (vol. VII, 1921, p. 373). A short summary of this paper was communicated to the meeting of Mycologists at Pusa in February of this year and appears in the Proceedings.

V. Programme and Publications.

Programme, 1921-22. Investigations, on the lines indicated in the annual reports and in the publications of the Section, will be continued on the following crops—cereals, tobacco, fibre plants, pulses, oil seeds, fodder crops and fruit—and on soil aeration and root development.

Publications. Seven papers were sent for publication during the year :—

1. The improvement of crop production in India. *Journal of the Roy. Soc. of Arts.*, vol. LXVIII, pp. 555 and 569, 1920.
2. The influence of soil factors on disease resistance. *Annals of Applied Biology*, VII, p. 373, 1921.
3. Some aspects of the Indigo industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo. *Mem. of the Dept. of Agr. in India* (*Botanical Series*), X, p. 1, 1920.
4. The saving of irrigation water in wheat growing. *Bulletin 118, Agr. Research Institute, Pusa*, 1921. (*In the press.*)
5. The Agricultural Development of Baluchistan. *Bulletin 119, Agr. Research Institute, Pusa*, 1921. (*In the press.*)

6. Pussa 12 and Pusa 4 in the Central Circle of the United Provinces (with Mr. B. C. Burt). *Bulletin 122, Agr. Research Institute, Pusa,* 1921. (*In the press.*)
7. Safflower oil (with Mr. J. Stewart Remington). *Bulletin 123, Agr. Research Institute, Pusa,* 1921. (*In the press.*)

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(F. J. Warth, M.Sc.)

I. Administration.

Dr. J. Sen was in charge of the Section till he was relieved by me on the 21st January, 1921.

II. Education.

Mr. K. Warriar, a student from the Cochin State, joined this Section on the 22nd June, 1921, for one year's training in agricultural chemistry.

III. Meeting of Agricultural Chemists.

The Second Meeting of Agricultural Chemists was held at Pusa on the 7th February, 1921, and following days. The proceedings of this meeting and the resolutions adopted have been printed and circulated and call for no special reference here.

IV. Meteorology and drain-gauges.

The usual meteorological and drain-gauge records were maintained.

V. General analytical work and assistance given to other Sections.

A. The following samples were analysed and reported upon during the year under report :—

Soils	6
Manures	41
Feeding stuffs	64
Sugarcanes	95
Milk	347
Cotton seeds	24
Water	14
Soda arsenate	2
Essential oil	3
Total	596

B. The following assistance was rendered to other Sections :—

Agricultural Section. Ninety-five samples of sugar-cane, 20 samples of manures and 347 samples of milk were reported upon.

Botanical Section. Sixty-four samples of feeding stuffs, 1 sample of soil, 6 samples of linseed, and 105 samples of soil for nitrates and 5 for organic and total nitrogen were analysed.

Mycological Section. Two samples of arsenate of soda were analysed.

Cotton Specialist. Twenty-four samples of cotton seeds were examined.

Sugar Bureau. One sample of sugar scum was analysed for the Secretary, Sugar Bureau.

Imperial Bacteriological Laboratory, Muktesar. Eleven samples of feeding stuffs were examined.

VI. Methods of Analysis.

The work reported on last year was continued and has been completed. The following conclusions were arrived at.

(*a*) *Organic nitrogen determination by the Kjeldahl method.* Seven modifications of the process, including the Gunning, Gunning Arnold, Dyer, and Pusa methods, were tested. Determinations by each method were made on 3 pure organic substances, on oil-cake, bone-meal and indigo *seet*, on calcium cyanamide and on tobacco stem. For most purposes the Pusa method was found to be both quick and effective. For refractory material such as tobacco stems the Dyer method gave the highest results with least trouble. On the strength of the data submitted to the Chemists' Conference these two processes were recommended by the conference for general use.

Experiments were also made on the determination of total nitrogen, including organic and nitric nitrogen, by

the Kjeldahl process. Reduction by thiosulphate was found to be easier and more accurate than reduction by iron.

(*b*) *Determination of nitric nitrogen.* The following methods were tested :—Reduction in alkaline solution with aluminium (Burgess); reduction by iron in acid solution (Ulsch); Warrington's gasometric method; the colorimetric method using phenol disulphonic acid; the nitron method.

Ulsch's method was found to be easy, rapid and satisfactory even in the presence of organic matter. On the strength of the data obtained at Pusa this method was recommended for general use by the Chemists' Conference.

The colorimetric method gave excellent results with quantities of nitrate = 0·2 to 0·1 mg. nitrogen. The effect of chlorides on the reaction was studied. It was shown that, when working with quantities equivalent to 0·1 mg. nitrogen, chlorides had no measurable effect unless the amount of Cl exceeded 15 parts NaCl to 100 parts KNO_3.

(*c*) *Phosphoric acid.* Results by gravimetric and volumetric methods were submitted to the conference at which the American volumetric method was accepted provisionally. Since then further work on this subject has been carried out by Mr. Iyer. He obtained interesting results which will be published as an appendix to the Bulletin of recommended methods now being prepared.

VII. Sugarcane.

Mr. Sanyal has continued his study of the sugarcane enzymes and the conditions under which favourable results from windrowing can be obtained. In the study of the enzyme it was found that the usual thymol solution was not sufficiently toxic to suppress bacterial activity. Thymolated alcohol was found to be more effective in certain cases. The retarding effect of thymol on invertase was also studied.

Considerable improvement in this work has been attained by aiming at the production of purer juices.

Windrowing was tested under field conditions prevailing at Pusa and under regulated laboratory conditions.

One of the results obtained in the field is worth noting. Data are shown in the accompanying table :—

	Date of analysis	% Juice extract	Juice composition		
			% Sucrose	% Glucose	% Ratio
Fresh cut, 10th February 1921.	10-2-21	64·9	16·60	1·01	6·24
Windrowed, 10th February 1921.	16-3-21	62·5	17·65	2·70	15·31
Fresh cut, 16th March 1921.	16-3-21	59·3	13·16	2·93	22·22

Cane was cut on the 10th of February and windrowed. It was examined on the 16th of March. Uncut cane left to grow in the field was cut and tested on the same day.

The windrowed cane was found to be decidedly superior to the cane which had been left standing uncut.

The laboratory experiments included one series to determine the maximum temperature at which windrowing could be done successfully. The changes in enzyme activity at the different temperatures tested were studied simultaneously. The work must be carried further before results become available for discussion.

VIII. Examination of soil gases.

The work on soil gases has been continued by Mr. Mukerji. CO_2 determinations on grassed and cultivated land were carried out throughout the year. The

results for two complete seasons are now available and are given in the accompanying table :—

Variation of CO_2 in soil gas. May 1919—April 1921.

Months	Plot No. 1 Grassed down		Plot No. 2 Grassed but partially aerated by trenches		Plot No. 3 Surface cultivated	
	1919-20 % CO_2	1920-21 % CO_2	1919-20 % CO_2	1920-21 % CO_2	1919-20 % CO_2	1920-21 % CO_2
May . .	0·271	0·385	0·257	0·315	0·133	0·236
June . .	0·341	0·544	0·274	0·524	0·249	0·275
July .	1·540	1·113	1·090	0·906	0·304	0·334
August . .	1·590	2·036	0·836	0·993	0·401	0·307
September .	1·908	2·212	0·931	1·167	0·450	0·341
October . .	1·297	1·545	0·602	0·718	0·365	0·291
November. .	0·853	0·647	0·456	0·420	0·261	0·254
December .	0·398	0·441	0·327	0·341	0·219	0·277
January . .	0·342	0·375	0·250	0·294	0·186	0·247
February . .	0·382	0·331	0·342	0·282	0·238	0·248
March . .	0·457	0·315	0·383	0·302	0·236	0·233
April .	0·367	0·514	0·321	0·430	0·222	0·315

It will be seen that the fluctuations due to season and cultivation respectively were very similar during the two seasons.

The abnormal figures for March 1920 and April 1921 must be attributed to the rain which fell a few days before each of these determinations.

The ratio of oxygen to CO_2 in the soils has been determined and shows striking differences between the grassed and cultivated plots. The ratio for the latter was found to vary between 86 and 60, whilst in the grassed plots the corresponding figures were 63·6 and 8·3.

Simultaneous nitrate and moisture determinations have shown the necessity for experiments along different lines. Some pot cultures have been commenced.

IX. The soil of the experimental area.

The main work this year has been the collection and examination of soil samples from selected patches yielding good and bad crops respectively.

A few striking differences in soil composition have been found. Where such differences occur they can be definitely correlated with crop development.

On the other hand, in a considerable number of patches differences in growth have been observed where the soil composition is to all intents and purposes uniform. There is therefore another factor involved in these growth differences. It has so far not been brought to light.

To determine the extent to which these patches of good and bad growth persist from year to year accurate crop maps of 5 plots have been prepared for comparison with succeeding crops.

X. Availability of P_2O_5 in relation to soil organic matter.

This work includes pot cultures and laboratory examination of soils. At this stage results are not available for discussion.

XI. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

Owing to the illness of Mr. Das who was engaged on the enquiry, the laboratory work connected with it has been temporarily suspended. Pot cultures are being continued.

XII. Programme of work for 1921-22.

Major.

1. Continuation of the investigations into the amount and nature of drainage water from cropped and fallow land.

2. The influence of manurial treatment of the soil on the composition of crops.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. A laboratory study of the changes occurring in windrowed cane.

5. The formation of carbon dioxide in soils and its effect on plant growth.

6. An investigation of the factors causing irregular plant growth in Pusa soil.

Minor.

1. Checking the accuracy of certain analytical methods.

XIII. Publications.

Proceedings of the Second Meeting of Agricultural Chemists held at Pusa on the 7th February, 1921, and following days.

Harrison, W. H. . The gases of swamp rice soils, Part VI. Carbon dioxide and hydrogen in relation to rice soils. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. V, No. 8.

Harrison, W. H., and Das, S. The retention of soluble phosphates in calcareous and non-calcareous soils. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. V, No. 9.

Harrison, W. H., and Sanyal, P. B. The effect of windrowing on the composition of sugarcane. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. V, No. 10.

Mukerji, J. N. . The excretion of toxins from the roots of plants. *Agri. Jour. India*, Vol. XV, Pt. 5.

Sanyal, P. B. . . The plant *Carica Papaya* and its enzyme. *Agri. Jour. India*, Vol. XVI, Pt. 5. (*In the press.*)

Sen, J. . . . Report on Agricultural Chemistry, 1919-20, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(J. H. Walton, M.A., M.Sc.)

I. Administration.

I held charge of the Section throughout the year.

Mr. N. V. Joshi, First Assistant, acted as Assistant Bacteriologist, and Mr. K. S. Viswanatham as First Assistant.

I regret to report the death of Babu Nitai Pada Nundi, who had most efficiently filled the post of fieldman since 1st November, 1913.

II. Training.

Mr. Fazal-ud-din, a private student, was under training from 24th September, 1920, and Babu Indubhusan Chatterji, Assistant to the Agricultural Chemist, Bengal, was deputed here for training from 20th April, 1921.

Owing to the lack of quarters on the estate, I was unable to admit any more students.

Two new assistants and a fieldman have also been under training from the time they were appointed.

III. Soil Biology.

Nitrogen. The losses of nitrogen from cattle dung and urine during storage under aerobic and anaerobic conditions were determined. The losses from the dung were comparatively small, but the urine lost 85 per cent. of its nitrogen under aerobic, and only 15 per cent. under the anaerobic conditions.

Nitrification. Pot experiments with oats manured with cowdung and urine stored under different conditions showed that the yields correspond to the amount of nitrate formation in nitrification experiments in the laboratory.

Similar results with oats were obtained from pots and

plots manured with green manure, including roots, stems and leaves taken separately, and the whole plant.

Phosphate solubilisation. A series of experiments on solubilisation of rock phosphate by composting with cake or green manure has been started. These experiments are far from completion, but results up to the present indicate that, even in so highly calcareous a soil as that of Pusa, solubilisation of phosphate by composting does take place.

Mahua cake. Experiments on nitrification of *mahua* (*Bassia latifolia*) cake showed that the addition of fresh cake lowered the percentage of nitrate nitrogen in the soil to zero. This effect persisted for about four weeks, after which small quantities of nitrate were found, but these in no case exceeded those present in the soil at the beginning. Nitrification of the cake was not improved by simple fermentation, but composting the cake with Trichi rock phosphate, or with rock phosphate and sulphur, for four weeks has resulted in 25 per cent. of the nitrogen of the cake becoming nitrifiable, and in one case the nitrate formed rose to 45 per cent.

The possibility of rendering the at present unavailable nitrogen of the *mahua* cake and phosphate of rock phosphate of service to crops is the subject of further investigation.

Biological analysis of soils. Samples of acid soil from Shillong were examined and reported on. Acid and silt soils from Eastern Bengal are now being studied.

IV. Indigo.

The investigations on use of pure cultures of bacteria for the improvement of the process of indigo manufacture have been carried on in conjunction with the Indigo Research Chemist during the past year which includes the season 1920 and part of season 1921, and, after many disappointments, promising results have at last been obtained.

The necessity for such investigations was rendered the more urgent owing to the most discouraging yields obtained

in May and June 1920 at the small indigo factory that had been started at Panchnoi, Assam.

Consideration of the analyses of indigo plant grown in Assam showed that, with an efficiency of vat working equal to that ruling in Bihar, a yield of about 25 seers of 60 per cent. cake indigo per 100 maunds of plant should be obtained.

At Panchnoi, however, very irregular results were obtained. The yield varied from 3 to 13 seers of indigo per 100 maunds of plant, and the quality from 31 to 53 per cent. The higher quality yields were obtained on only one or two days a week.

Samples of the water used at Panchnoi were examined at Pusa, and under laboratory conditions were found most unsatisfactory for the production of indigo. With these waters, fermentation of indigo leaf extract did not begin until after 36 to 40 hours, whereas, with river water at Pusa, fermentation started in 12 hours.

I visited Panchnoi at the end of July 1920, and counts on indigo leaf extract agar plates made on six days showed that the number of hydrolysing bacteria per cubic cm. of water varied from ten to several thousands. The produce on the days of the low counts was poor, averaging about 7 seers of 41 per cent. indigo per 100 maunds plant, while on two days of high count, the results were 17·5 seers of 53·9 per cent. cake and 26·6 seers of 48·2 per cent. cake. Inoculation of one vat with a culture of a hydrolyser brought from Pusa gave no satisfactory result, for unfortunately the day chosen was one when the water had an exceptionally high bacterial content.

Further experiments on the effects of inoculation of the steeping water with a pure culture of hydrolysing bacteria were carried out at Pusa in August. The results of the inoculation were most unsatisfactory. Taking into consideration quantity and quality of the produce, the inoculated vat was definitely inferior to the control vat in which ordinary river water was used. The quality of the produce from the inoculated vat was in almost every case lower

than that of the control vat. It was therefore considered that the time of steeping of the inoculated vat might be too long.

At the Panchnoi factory very irregular results were being obtained, till the Manager increased the time of steeping to 20--24 hours. High yields were obtained, but the quality was still poor, only 48 to 55 per cent.

Mr. Davis, Indigo Research Chemist, having devised a test (vide *Indigo Publication No. 8, Appendix*) by means of which the optimum time of steeping might readily be ascertained, this was applied and used at Panchnoi in November, and the plate counts were made of the hydrolysing bacteria in the water. The numbers varied between much narrower limits than they had done in July, namely, from 40 to 170 per c.c., while the correct time of steeping at 90° F. was found to be about 16--18 hours. On four days, near the end of the *mahai*, the time of steeping was about 14 hours, and indigo of over 60 per cent. quality was made on these days.

Vat trials at Pusa were started again in the season 1921. The results of the first part of the season only are available. Inoculation of unsterilized *khajanah* water with a pure culture of indican hydrolyser did not give very good results, nor did sterilization of the *khajanah* water with permanganate and subsequent inoculation. In the latter case exceptionally high acidity developed in the extract, and high acidity is always associated with low quality produce.

Sterilization of *khajanah* water with "E.C." was next tried, and preliminary experiments having shown that twelve hours after sterilization with "E.C." the sterilized water did not kill the indican hydrolysers, the *khajanah* water was sterilized twelve hours before the addition of the inoculum. The first day's working gave produce of the remarkably high quality of 78·5 per cent. which is probably the highest ever obtained in Bihar. This quality, moreover, was obtained from liquor that had been oversteeped for at least one hour, when some falling off in the quality

of the produce is to be expected. Further trials will be carried on during the remainder of the present season.

V. Water sterilization: "E.C."

Throughout the year under report "E.C." was manufactured in the laboratory for use in sterilization of the wells on the Pusa Estate, and in the last six months supplies have been made for the Civil Surgeon, Muzaffarpur, who has used it both for sterilizing wells and for surgical dressings. For the treatment of septic wounds and sores it has proved wonderfully effective, and in one day has cleaned up what seemed to be hopeless cases, and thereby saved limbs from amputation.

The small plant in the laboratory is now working at full pressure to keep pace with the current demand from the Muzaffarpur and Darbhanga Districts, in which an output many times larger than the present one could be very usefully employed in hospitals, dispensaries and for disinfection of wells. Its value as a sterilizer of the *khajanah* water for indigo manufacture with pure cultures of bacteria is referred to above.

VI. Fermentation organisms.

Yeasts. Strains of yeasts from various sources were isolated and their efficiency in the fermentation of molasses tested. In laboratory trials a yeast from Nellikuppam yielded 90 per cent. of the theoretical maximum output of alcohol.

VII. Plant diseases.

Potato. Samples of diseased potatoes were received from Assam. A rot-producing organism was isolated. Artificial inoculation of potatoes with this organism, in the dry season April-May, were unsuccessful in producing rot, even when the potatoes were kept in a moist chamber for several weeks, but at the beginning of the rains inoculation with the same organism produced rot in three or four days.

Onion. A bacterial rot of onion is under investigation.

VIII. Programme of work for 1921-22.

Major.

1. *Soil biology—*
   (*a*) Nitrogen fixation.
   (*b*) Relationship between bacterial activities and the decomposition of organic manures.
   (*c*) Influence of bacterial action on the solubilisation of phosphates.
   (*d*) Training of students and assistants.
2. *Special enquiries—*
   (*a*) Indigo manufacture.
   (*b*) Alcoholic fermentation.

Minor.

(*a*) Bacterial diseases of plants.
(*b*) Revision of laboratory methods.

IX. Publications.

Hutchinson, C. M. . Pebrine in India. *Mem. Dept. Agri. India, Bact. Ser.*, I, No. 8.

Walton, J. H. . Report on Agricultural Bacteriology, 1919-20, for the Board of Scientific Advice.

Joshi, N. V. . Studies in Biological Decomposition of Cow-dung and Urine in Soil. *Agri. Jour. India*, XV, No. 4.

Joshi, N. V. . Studies on the Root Nodule Organism of the Leguminous Plants. *Mem. Dept. Agri. India, Bact. Ser.*, I, No. 9.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.)

I. Charge and Establishment.

Dr. E. J. Butler held charge of the Section until 22nd July, 1920, when he went on leave prior to taking up his appointment as Director, Imperial Bureau of Mycology, London. Mr. W. McRae, Government Mycologist, Madras, took over charge from Dr. Butler and held office until 4th January, 1921, when he proceeded on leave. Dr. Shaw returned from leave on 23rd December, 1920, and took over charge of the Section on 4th January, 1921. Mr. J. F. Dastur, Supernumerary Mycologist, returned from his period of deputation in England on 13th December, 1920, and has officiated as Second Imperial Mycologist since 4th January, 1921.

Mr. McRae officiated as Joint Director for several months, and this combined with the absence of Dr. Butler, Dr. Shaw and Mr. Dastur considerably affected the output of mycological work in the Section.

During the year under review Dr. E. J. Butler was decorated with the C.I.E., and as the result of his studies in England Mr. J. F. Dastur obtained the D.I.C.

II. Training.

Pandit S. D. Joshi, B.Sc., a stipendiary student of the United Provinces Government, who joined the Section on 12th June, 1919, completed his period of training and left the Section on 31st May, 1921. Mr. L. S. Bertus of the Ceylon Agricultural Department joined the Section on 6th September, 1920, for one year's training. Mr. P. D. Nair, L.Ag., Assistant to the Government Mycologist, Central Provinces, joined for one year's training on 31st May, 1921.

III. Mycological Conference.

The Third Conference of Mycological Workers was held in Pusa on 7th February, 1921, and the following days. The proceedings of the conference have been already published.

IV. Diseases of Plants.

(1) Cereal diseases. The study of the genus *Helminthosporium* on cereals and sugarcane was continued by Mr. Mitra. The cultural study of the species found on maize, *jowar* (*Andropogon Sorghum*), sugarcane, rice, wheat, and barley was completed. All these together with the four strains on wheat were cultivated on a large number of media of different chemical constituents and also on sterilized straw of paddy and wheat. They were also kept at different temperatures. No perfect stage of any of them was discovered. Some of the species kept constant characters in a particular media when grown on it repeatedly but others such as *H. teres* Sacc. on barley, *Helminthosporium* on wheat from Pusa and Burma, and *Helminthosporium* on sugarcane showed occasional change in the character of growth and also in the size of spores formed. Thus *H. teres* Sacc. of barley has sometimes a dark growth, sometimes a snowy white and woolly growth, and occasionally a pinkish white growth. Similarly *H. Sacchari* Butl. generally produces a good aerial growth but sometimes a subculture gives a creeping dark mycelium full of spores and with very little aerial growth. Again a subculture from this may give rise to an aerial growth or may keep the character of the parent culture for some time and then again revert to its old habit. Spores are also variable in size. *H. teres* Sacc. on barley produces pycnidia and chlamydospores on sterilized wheat straw; the latter have not been described before.

The study of *Helminthosporium* on maize and *jowar* is concluded. The species on maize and *jowar* appears to be two different strains of *H. turcicum* Pass. It is interesting to note that *Helminthosporium* is found on maize only,

and not on *jowar*, in Bihar, and *vice versâ* in the Punjab. From the results of cross-inoculations it is concluded that there is no specialization of parasitism and that the fungus from one host can infect others. Thus cross-inoculations with *Helminthosporium* on maize and *jowar* give reciprocal results and infections are also successful on sugarcane, wheat, barley, oat and to some extent on paddy but not on *bajra* (*Pennisetum typhoideum*). Rice and sugarcane *Helminthosporium* give positive results when cross-inoculated on maize, *jowar*, wheat, oat, barley, rice and sugarcane. All the four strains on wheat give positive results on rice, maize, *jowar*, oat and barley and some also on sugarcane. *H. teres* Sacc., which does a good deal of damage to barley in Pusa, was inoculated with success on wheat, maize, rice, *jowar*, and oat.

H. gramineum Rabh., the cause of Stripe disease of barley, is sometimes very dangerous to this host. This year there was a serious outbreak of Stripe disease on "cape" barley and the whole plot was completely destroyed. The neighbouring plots in which other varieties of barley were growing appeared to resist the disease; cross-inoculations, however, give positive results.

Helminthosporium on wheat, one of the causes of "foot rot," was obtained from America and is being compared in culture with the forms on wheat and barley occurring in Pusa. On sterilized wheat straw, it agrees very much with *H. teres* Sacc. on barley and on wheat in Pusa. *Helminthosporium* on barley and oat does good deal of damage to seedlings and young plants. Last year it was present to a large extent on oats. It is intended to try control measures by treating the seeds before sowing.

Acrothecium lunatum Wakker has been found on *Setaria italica* Beauv., *Panicum frumentaceum* Roxb. and *Eleusine coracana* Gaertn. It forms small elliptical or elongated brownish or straw colour spots but is not very common. It occurs on many other plants also and appears to be a weak parasite. A memoir was published on *Acrothecium Penniseti* n.sp. on *bajra*.

Smut on *kodra* (*Paspalum scrobiculatum* L.) was studied and various methods were tried to find out the mode of infection but no definite results were obtained. *Kodra* seeds were mixed with smut spores and then treated with copper sulphate solution (0·5, 1·0, 1·5, 2·0, 2·5, and 3·0 per cent.) for ten minutes and sown. In some control plots untreated seeds were also sown. None of the treated seed produced smut but smut appeared in plots in which untreated seeds were sown.

(2) Miscellaneous. The research work on diseases of paddy caused by *Piricularia* was continued by Mr. McRae.

The investigation of chilli diseases is being carried on by Mr. Dastur: the results of the work on *Choanephora* and anthracnose of this crop were published during the year under review and a paper dealing with " die back " is in the press. A paper on the mode of infection of sugarcane with smut disease was published and the causes of the immunity of thick canes to this disease are being studied in the light of this new information.

Work on diseases of jute was resumed during the rainy season of 1921. Investigations were commenced on diseases of areca palms in Assam and on a suspected outbreak of bud rot of palmyra palms in the Burdwan District of Bengal. The resumption of the work on orchard diseases was seriously hampered by the failure to obtain the necessary spraying apparatus from Europe in time for the present season.

During the year under review the " Fiji " and " Mosaic " diseases of sugarcane and the disease of rubber caused by *Fusicladium macrosporum* Kuyper were added to the list of prohibited diseases in the Government of India Notification under the Destructive Insects and Pests Act.

V. Systematic work.

Three hundred and eighty specimens were added to the herbarium during the past year. Steps are being taken to publish a host and fungus index of the mycological her-

barium at Pusa for the assistance of the new sections of mycology in the provincial departments of agriculture and for general information. *Urocystis coralloides* Rostrup, a rare smut on mustard, was discovered for the first time in India in the vicinity of Pusa and identified at the recently created Imperial Bureau of Mycology.

VI. Water hyacinth.

During the months of May and June assistance was given to the Bengal Department of Agriculture in testing the efficacy of spraying as a method of destroying water hyacinth (*Eichornia Crassipes* Solm.). The spray used was a secret proprietary mixture which has been found satisfactory in other parts of the world in the eradication of prickly pear. The results of the experiments showed that—

(1) the spray killed water hyacinth in accordance with the claim of the inventor;
(2) it was non-poisonous to live stock;
(3) it could be easily applied by means of a sprayer of the usual type;
(4) rain did not interfere with its efficiency.

It was found that 1 gallon of the spray fluid would destroy 24 to 30 square yards of water hyacinth and with more efficient machinery this area could probably be doubled. The inventor states that the fluid costs 0·3 penny per gallon. This would make the cost of material for spraying 5 or 6 shillings per acre at the most. Spraying against water hyacinth is carried out in certain States of America where a solution of sodium arsenite is used but the poisonous properties of this spray might render dangerous its employment in India. The results of the experiments carried out suggest that a possible remedy against water hyacinth is at our disposal and call for further investigation.

VII. Programme of work for 1921-22.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The

following crops and diseases will receive special attention :—

(*a*) Diseases of jute.
(*b*) Foot rot of cereals.
(*c*) Stripe disease of cereals.
(*d*) Orchard diseases.
(*e*) Sugarcane diseases.

(2) *Systematic work.* This will be carried out in conjunction with the Imperial Bureau of Mycology in London.

(3) *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VIII. Publications.

Dastur, J. F. . . Die-back of Chillies (*Capsicum* spp.) in Bihar. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 5. (*In the press.*)

,, ,, . . The Mode of Infection by Smut in Sugarcane. *Annals of Bot.*, Vol. XXXIV, July 1920.

,, ,, . . *Choanephora Cucurbitarum* (B. & Kev.) Thaxter on Chillies. *Annals of Bot.*, Vol. XXXIV, July 1920.

,, ,, . . *Glomerella cingulata* (Stoneman) Spauld. and v. Sch. and its conidial forms, *Glœosporium piperatum* E. and E. and *Colletotrichum nigrum* E. and Halst., on Chillies and *Carica Papaya*. *Annals of Applied Biology*, Vol. VI, No. 4, April 1920.

McRae, W. . . Report on Mycology, 1919-20, for the Board of Scientific Advice.

Mitra, M. . . . Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A New Disease of *Pennisetum typhoideum.*) *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 3.

Shaw, F. J. F. . . Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori* Syd. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 2.

Subramaniium, L. S. . The genus *Cerebella.* (*In the press.*)

Proceedings of the Third Meeting of Mycological Workers in India, held at Pusa on the 7th February, 1921, and following days.

List of Specimens in the Mycological Herbarium at Pusa. (*In the press.*)

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1921. On the death of Mr. F. M. Howlett, Imperial Pathological Entomologist, at Masuri on 20th August 1920, the Imperial Entomologist also took charge, at the verbal request of the Agricultural Adviser, of the Pathological Entomological Section in addition to his own duties. The post of Supernumerary Entomologist remained vacant throughout the year. Mr. R. Senior-White was given a temporary appointment as Entomologist from 1st November 1920, to 28th February 1921, to assist the Imperial Entomologist in sorting out the collection of Diptera. Mr. C. C. Ghosh, Insectary Assistant, was transferred to Burma from 1st October 1920 and relieved by Mr. B. B. Bose.

II. Training.

Mr. G. D. Austin, a student deputed by the Ceylon Department of Agriculture, was under training up to September 1920. Mr. S. C. Sarkar, a private student, was admitted in July 1920 and completed the ordinary course in elementary Agricultural Entomology in June 1921. Mr. P. V. Casling, I.M.D., attended the laboratory from 26th October to the end of December 1920 for a short course with especial reference to the study of Diptera of sanitary importance. Five students attended the short course in Lac-culture. Three students completed the full course in Sericulture and four others were under training at the end of the year; six other students were also given instruction in sericulture not amounting to a regular course.

III. Insect Pests.

The principal work done was a continuation of the investigation of Borers in sugarcane and other gramineous

plants, the results of which up to the end of 1920 were written up by Mr. C. C. Ghosh in a paper submitted to the Fourth Entomological Meeting and now in the press; there is therefore no need to repeat much of this information here. The experimental plots of sugarcane were under observation during the year and countings of dead-hearts in the various varieties were made to find out the percentage of damage, which is shown in the following table :—

Variety	Type	Date	Percentage of damage	Date	Percentage of damage	Date	Percentage of damage	Date	Percentage of damage
Sathi 131, Plot 33 . .	Thick	20-22-VII-20	22·7	22-26-VIII-20	22·8	17-XII-20 to 4-I-21	23·2	Grown cane harvestable	
Reora . .	Very thin	26-30-VII-20	12·2	27 VIII-20	11·4	...	...	...	...
Java	Medium thick	30-31-VIII-20	7·4	...	...	...	...	...	...
Maneria, Plot 40 . .	Medium thick	16-VII-20	14·1	21-23-VIII-20	13·6	22-23-IX-20	14·5	6-13-I-21	34·6
Purple Mauritius, Plot 29.	Thick	31-VII-20	42·2	20-VIII-20	39·8	18-20-IX-20	35·9	9-XII-20	26·3
Farm *Sathi* 131, Plot 31 .	Thick	31-VII-20	29·5	19-20-VIII-20	26·2	17-18-IX-20	17·3	10-15-XII-20	29·8

Examination of this table serves to confirm the statements, made in last year's report, that thin varieties of cane show a greater immunity from Borer attacks than do thick ones and that the percentage of attack generally and gradually decreases with the growth of the canes. The Java variety was observed to have a good stand and uniform growth when the countings were made in August. Dead-hearts and dry shoots occur practically wholly amongst young plants, those which are growing healthily being almost free. When the last countings were made in December and January it was found that a large number of each variety, harvestable so far as Borers were concerned, had been destroyed by jackals, rats and termites. Termites may in some cases, especially in dry soils, do extensive damage, as was instanced in the case of forty setts (each sett with three eyes) each of *Reora* (thin) and *Sathi* 131 (thick) varieties of cane planted in the Insectary compound in February 1921; these were attacked heavily by termites which destroyed the growing point and young shoots, so that at the end of the year under report only one shoot of *Reora* was still standing.

A bad attack by Aphids on an experimental crop of wheat was checked in a few days by the liberation in the field of large numbers of Coccinnellid beetles collected from other wheat areas on the farm.

An attack of Red Spider on jute was controlled by spraying with crude oil emulsion and sulphur.

Some work was done on the oviposition of *Monophlebus octocaudatus*, a Coccid which is usually a bad pest of fruit-trees and garden shrubs during the early part of the hot weather. In the case of peach trees, on which hundreds of adult females had been noticed in April, the eggs and remains of dead females were found in large numbers in June in the soil around the trunk of the tree within a radius of about six feet; in the case of dry soil, they occurred to a depth of about three inches, but where the soil was damp, as alongside the course of a water-channel, they were found up to six inches from the surface. All the eggs found

around one tree were collected as far as possible and counted and amounted to roughly 73,000. Experiments on the survival of the eggs under different conditions are in progress.

The following insect pests were noted as occurring on the Pusa Estate in destructive numbers :—*Epilachna dodecastigma* on brinjal seedlings; *Diacrisia obliqua* on jute, soybean, *Dolichos lablab* and cow-peas; *Chrotogonus* sp. and *Hellula undalis* on cauliflower and brinjal seedlings; *Euphalerus citri* on orange and lemon; *Bagrada picta* on radish. Besides these, numerous observations were made on various other insect pests.

Life-histories. Besides the various insects named above, about 130 different lots of insects have been reared during the year and observations made on life-histories and habits. Some of these are new to science, some have been found on new food-plants and most have not been reared before. It is only possible to mention a few of these here.

Sphyracephala hearseiana (Diopsidæ). The life-history has been worked out and the results written up by Mr. S. K. Sen in a Memoir, now in the press. Some study was also made of the anatomy of the adult fly. Dissection of the male reproductive tract revealed a pair of somewhat remarkable, partially convoluted organs, evidently testes, which, when fixed with Bless' fluid, on account of their brown colour stood in prominent relief against the colourless accessory glands.

Laphygma exigua (Noctuidæ) was found on the following new foodplants, *viz.*, *Colocasia antiquorum*, *Ranunculus scleratus*, *Polygonum glabrum*, and *Rumex maritimus*.

Prodenia litura (Noctuidæ) was also found feeding on *Polygonum glabrum*.

Agromyzid fly maggots were found mining the leaves of the following plants, *viz.*, *Inula vestita*, *Cnicus arvensis* (both Compositæ), *Nepta rudinalis* (Labiatæ), *Pisum arvense* (Leguminosæ), and *Brassica campestris* (Cruciferæ); but it remains to be determined whether they belong to one or more species.

Larvæ of *Stromatium barbatum* (Cerambycidæ), boring in dead wood, from eggs laid in June 1917, are still living.

Hæmatopota javana, Wied. (Tabanidæ) (Plate III) was reared from a larva found underground near the roots of indigo in a place where some *Panicum* grasses were also growing. The larva was found on 5th August, pupated 23rd August and emerged 28th August, 1920.

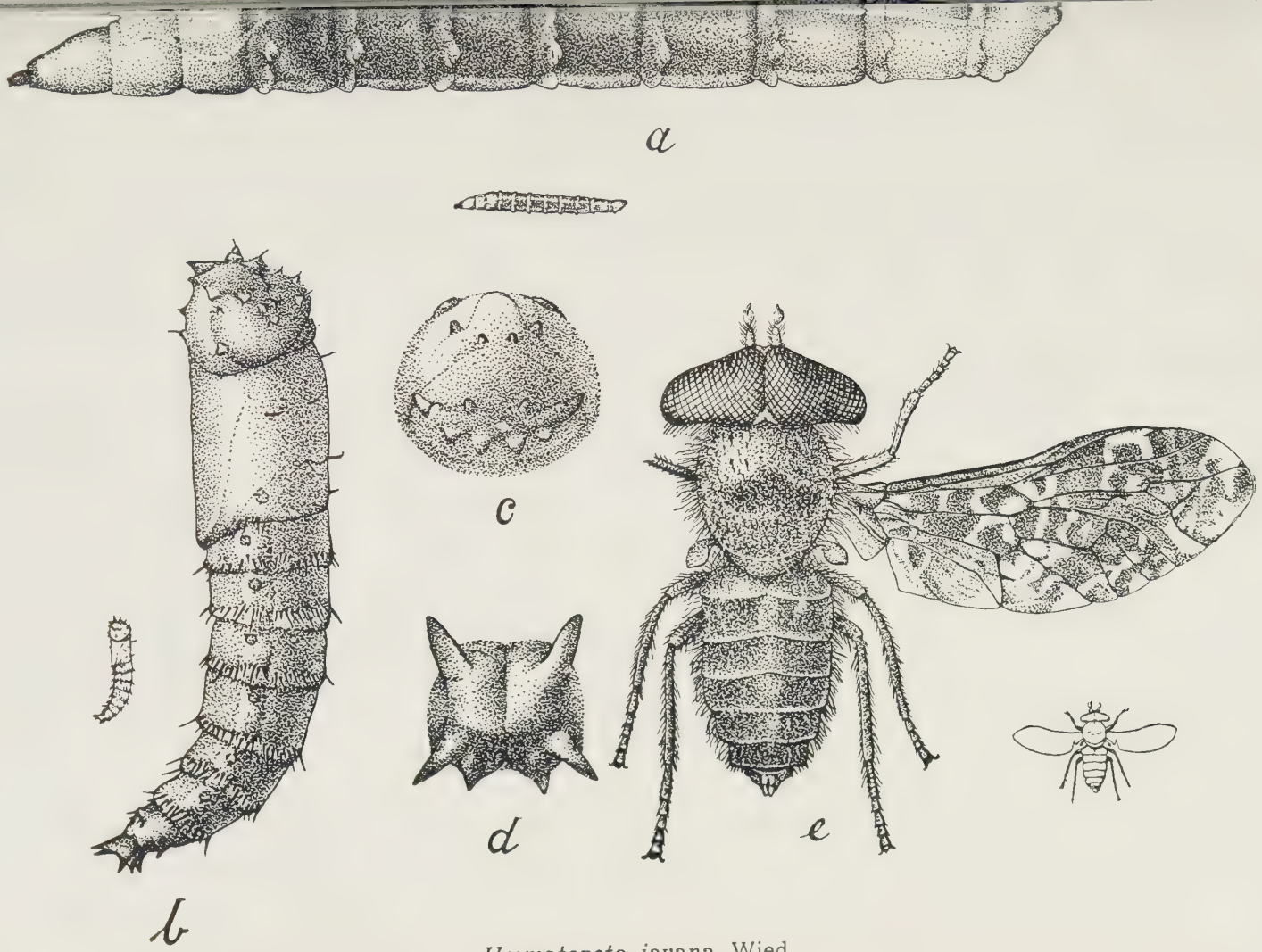
The larva of an Agromyzid fly (Plate IV, fig. 1) was found mining leaves of Rape (*Brassica campestris napus*) in January 1921. The maggots begin their mine near the apex of the leaf and work towards the base, the mines containing small pellets of frass. After mining halfway down the leaf on the upper surface the larva pierces through the tissue and continues its mine on the lower surface of the leaf. It pupates inside the mine, exposing its posterior pair of spiracles through the white epidermis of the leaf. The flies emerged during the first half of February.

Gonocephalum elongatum (Tenebrionidæ) (Plate IV, fig. 2) was reared in March and April from larvæ found on 16th February 1921 underground near the roots of *Polygonum plebejum;* the larvæ fed on the finer roots and on fallen leaves and apparently ate one another in confinement.

Exelastis pumilio, Zell. (*liophanes*, Meyr.) (Alucitidæ) (Plate V, fig. 1) was reared from a larva found feeding on a wild Vetch (*Alysicarpus vaginalis*) at Shillong. This is a very common species throughout India and had been reared at Pusa from a pupa found on *Oxalis*, but the larva had not been found before.

An Anthomyiad fly (C. S. 2108) (Plate V, fig. 2) was found boring *Dabhi* grass (*Imperata arundinacea*) in the larval stage and causing dead-heart, the flies emerging in November 1920.

Olenecamptus bilobus (Cerambycidæ) (Plate VI, fig. 1) was reared in November from larvæ found boring under the bark of a fallen *gular* (*Ficus glomerata*) tree. This



Hæmatopota javana, Wied.

a, Larva (× 9); *b*, Pupa (× 9); *c*, The top view of the head of pupa, magnified; *d*, Dorsal view of the posterior

PLATE III

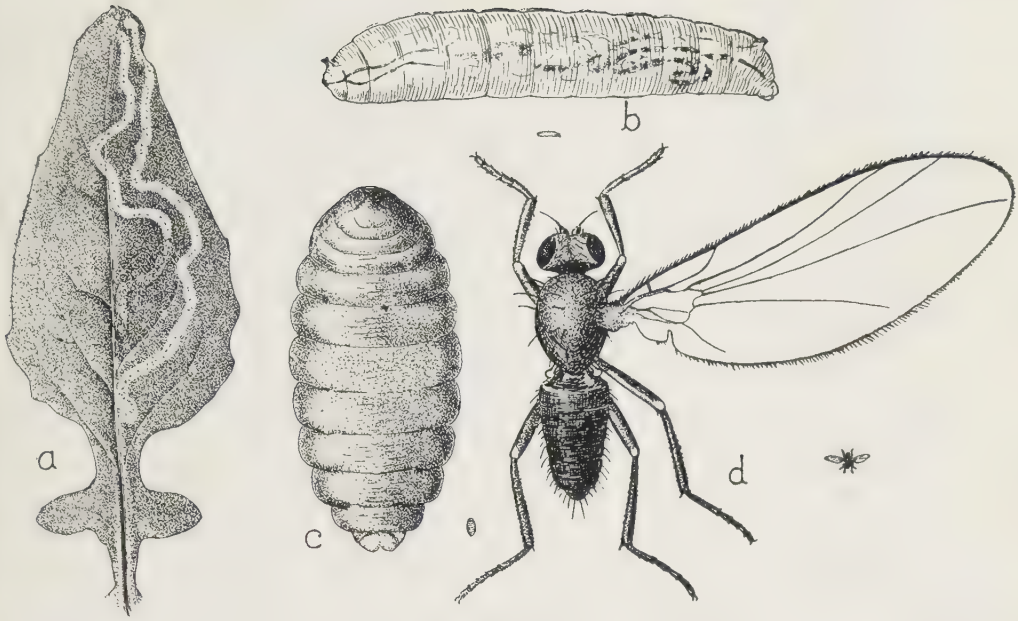


Fig. 1. An Agromyzid Fly (C. S. 2129).

a, Leaf of *Brassica campestris napus* mined by larvæ, natural size; *b*, Larva, extracted from mine (× 20); *c*, Pupa (× 20); *d*, Adult fly (× 20). The smaller figures against *b*, *c* and *d* show the natural sizes.

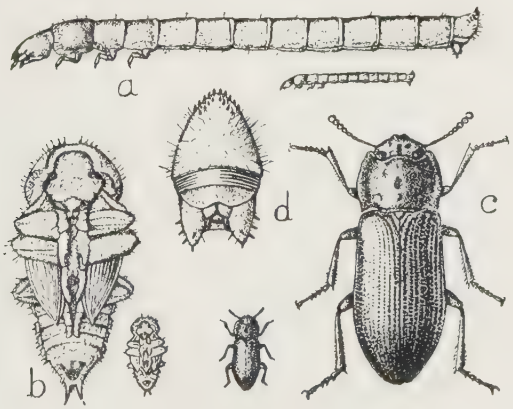


Fig. 2. *Gonocephalum elongatum.*

a, Larva (× 3); *b*, Pupa (× 3); *c*, Beetle (× 3); *d*, Posterior view of last abdominal segment of larva, magnified. The smaller figures alongside *a*, *b* and *c* show the natural sizes.

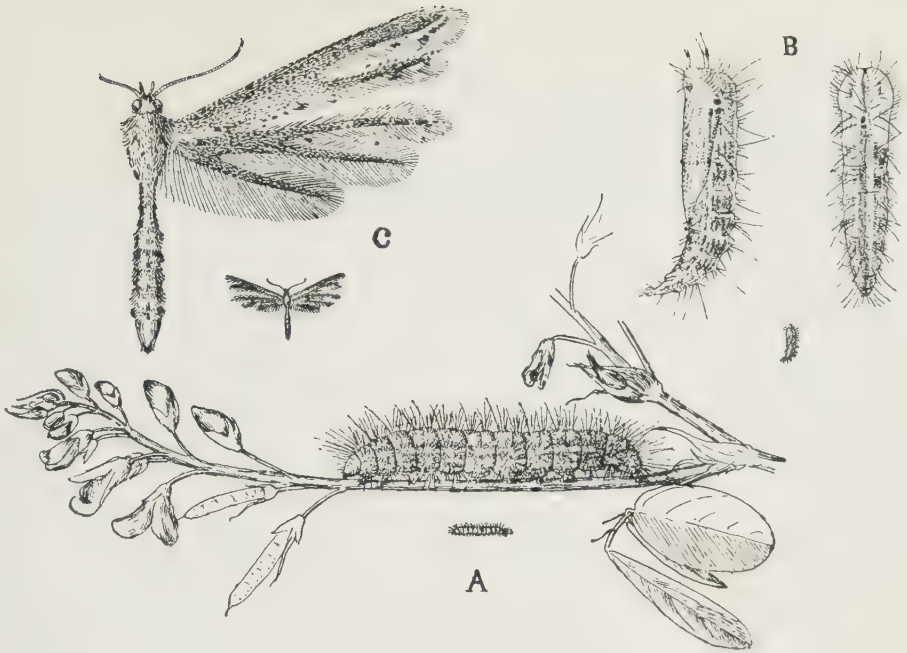


Fig. 1. *Exelastis pumilio*, Zell. (= *liophanes*, Meyr.)

a, Larva (× 5); *b*, Lateral and dorsal aspects of the pupa (× 5); *c*, Moth (× 5). The smaller figures show the natural sizes.

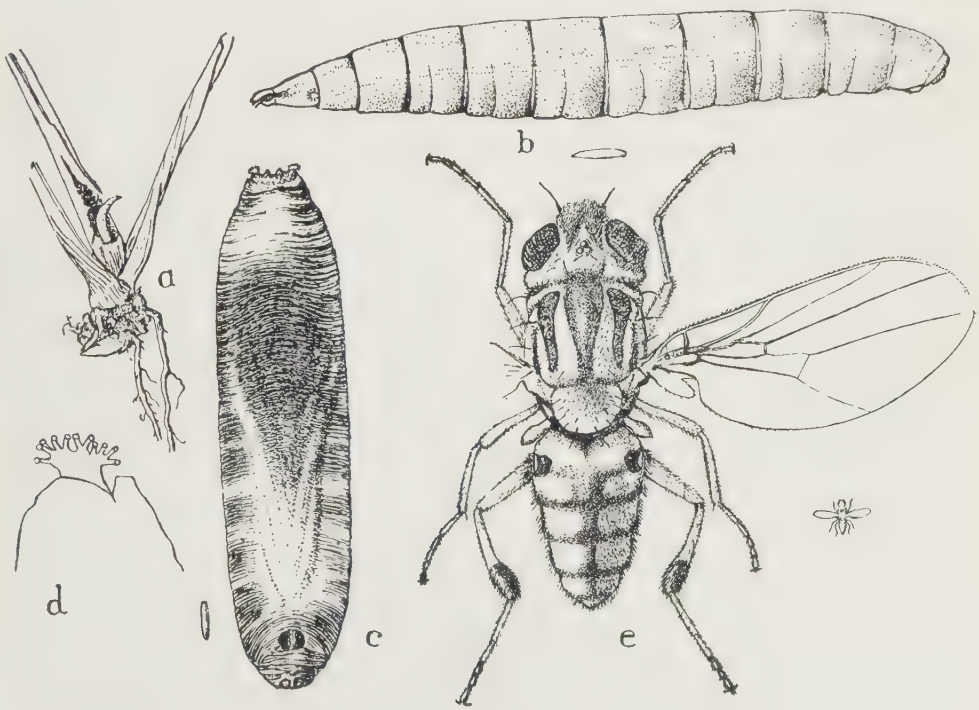


Fig. 2. Anthomyiad Fly in Dabhi grass stem (C. S. 2108).

a, Leafy stem showing the maggot boring it, natural size; *b*, Larva (× 13); *c*, Pupa (× 13); *d*, The left anterior tracheal opening showing division into tubules in the pupa, magnified; *e*, Fly (× 13). The smaller figures against *b*, *c* and *e* show the natural

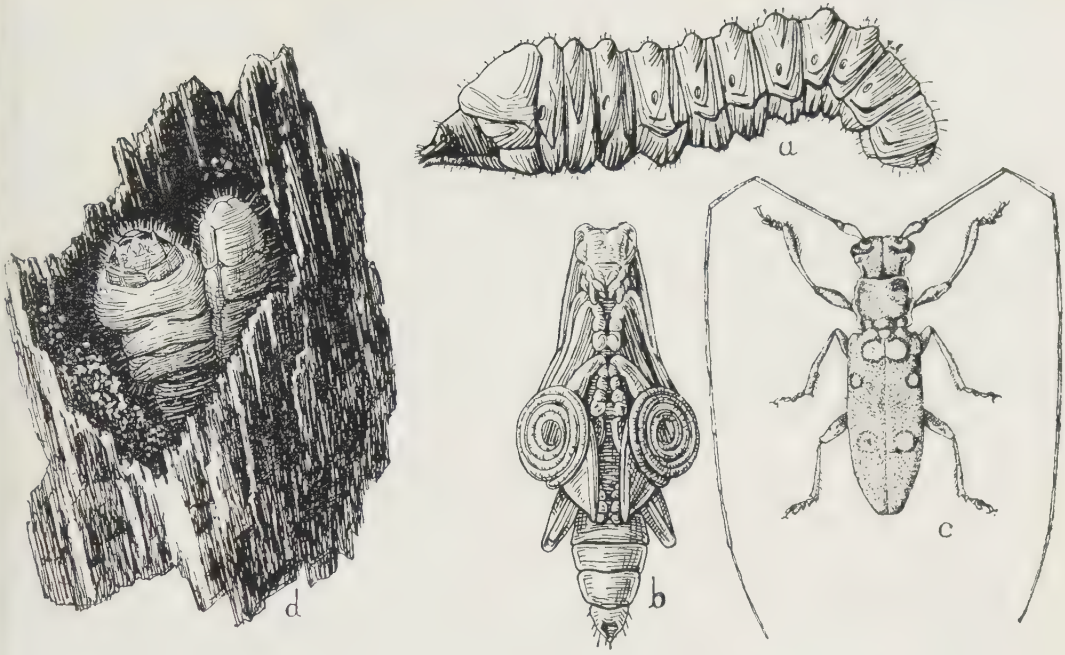


Fig. 1. *Olenecamptus bilobus.*

a, Larva (× 5); *b*, Pupa (× 5); *c*, Beetle (× 2½); *d*, Larva in situ (× 4).

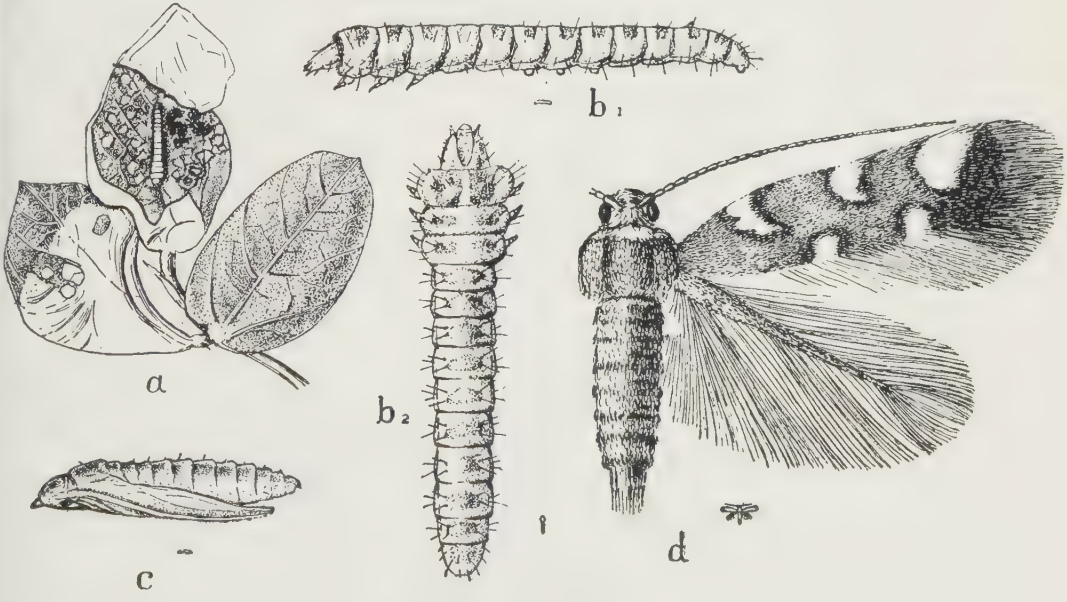
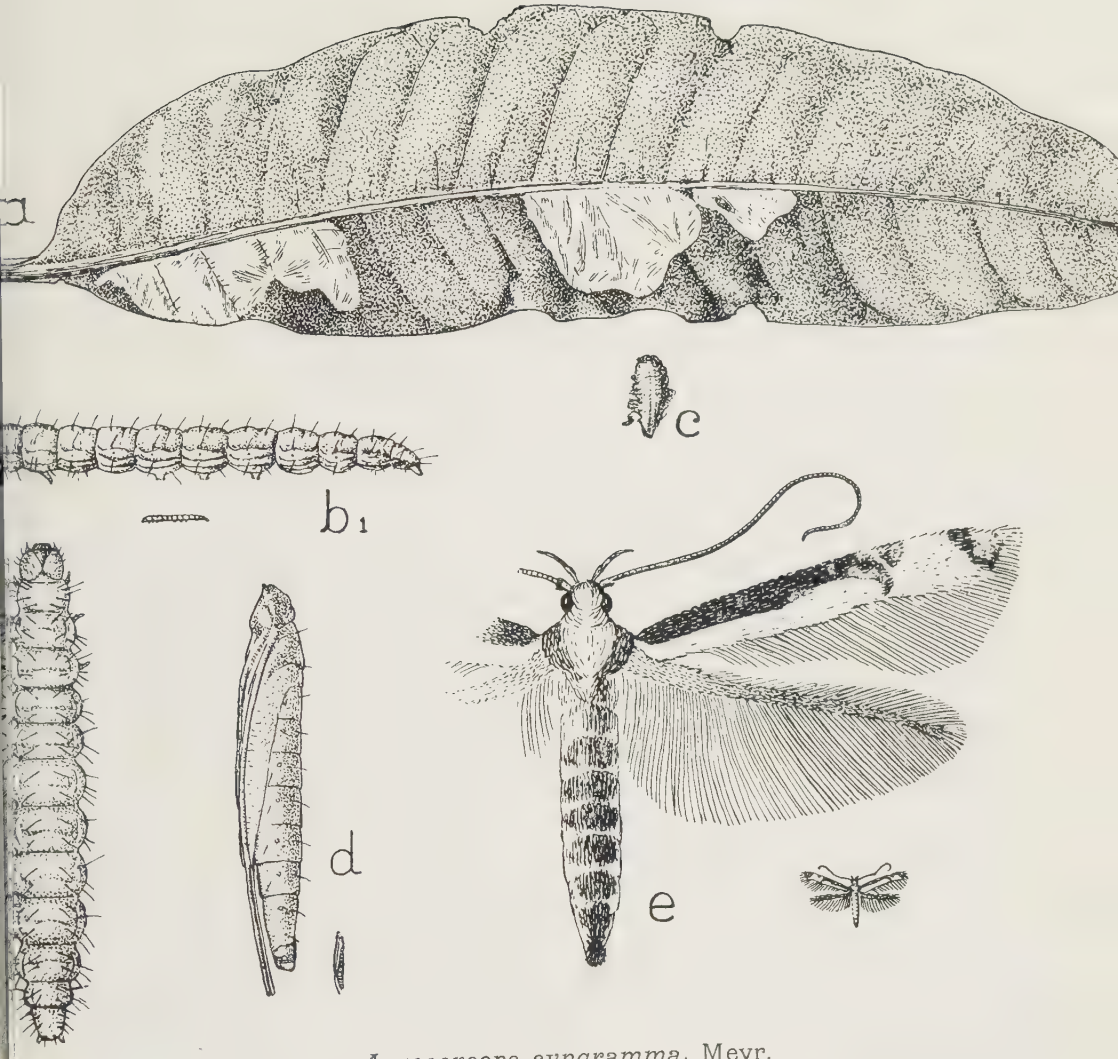


Fig. 2. *Lithocolletis neodoxa*, Meyr.

a, Mined leaf of *Ichhaini*, epidermis cut open to show the caterpillar (× 4); b_1, Lateral view of larva (× 24); b_2, Dorsal view of larva (× 24); *c*, Pupa (× 24); *d*, Moth (× 24).

The smaller figures against *b*, *c* and *d* show the natural sizes.



Acrocercops syngramma, Meyr.

a, Mined mango leaf, natural size; b_1, Lateral view of larva (× 12); b_2, Dorsal view of larva (×
coon, the irregular outline is the upper epidermis which sticks to the cocoon (× 1½); *d*, Pupa (×
h (× 12).

The smaller figures against *b*, *d* and *e* are 1½ times the natural sizes.

beetle is of common occurrence in wild fig trees throughout India and is at times a pest of cultivated figs.

Acrocercops syngramma, Meyr. (Gracillariadæ) (Plate VII) was reared from larvæ mining leaves of mango. This small moth occurs commonly throughout the Plains of India and is at times a minor pest of mango by mining the leaves. This species is referred to in Entl. Memoir, Vol. VI, p. 156, t. 40, f. 1, but the early stages have not been figured before.

Lithocolletis neodoxa, Meyr. (Gracillariadæ) (Plate VI, fig. 2) was bred in September and November from larvæ found mining leaves of *Rhynchosia minima* (Hindi, *Ichhaini*). The early stages of this species were also described in Entl. Memoir, Vol. VI, p. 141, but have not been figured previously.

Cosmophila sabulifera (Noctuidæ) (Plate VIII), of which a new Plate has been prepared, is a well-known pest of jute.

Pathological Entomology. Work under this heading (apart from the systematic side, dealt with under Insect Survey) has been continued mainly with reference to Tabanidæ, in connection with the Surra work, and Culicidæ.

In connection with the work on Surra, the services of Mr. P. G. Patel were placed at the disposal of the Camel Specialist, Sohawa, from 15th July to 30th September 1920 and again from 20th April 1921 until the close of the year under review, and in the intervening period Mr. Patel, when not on leave, was working at Tabanidæ at Pusa, mainly in collecting egg-masses to ascertain facts regarding the parasitization of these under natural conditions. During March 1921, *Tabanus albimedius*, *T. bicallosus* and a *Chrysops* were found ovipositing freely on leaves of *Polygonum*, etc., along the banks of the river; of these three Tabanids, the eggs of the first-named were found heavily infested by a Chalcidid of the genus *Phanarus*?, whilst the eggs of the other two species were comparatively lightly infested. The parasites were observed to oviposit in both

the upper and lower layers of eggs of *T. albimedius*, the upper layer usually producing male parasites and the lower layer females. The male parasites usually emerge 24 hours before the females and were noticed near the emerging females, apparently helping them in the act of emergence. Pairing takes place soon after the emergence of the females and oviposition occurs soon after the act of pairing. Under laboratory conditions, a single female was observed to oviposit seven times, but under natural conditions the number of eggs deposited is undoubtedly greater; three eggs were laid in four minutes. Tabanid eggs which are parasitized look darker than usual, especially at the ends, and the dark colour becomes more pronounced with the development of the parasite. Polyembryony was not found to occur in the case of this Chalcidid, and in several parasitized Tabanid eggs dissected it was found that a single egg harbours only one larva or pupa of the parasite. The life-cycle period of the parasite extends to nine days during the last week of March at Pusa, when the incubation period of *T. albimedius* eggs was six days.

On Mr. Howlett's death it became necessary to go into the question of the Surra work on which he had been employed to ascertain (1) what lines of work had been ordered to be done, (2) what had actually been done and (3) what recommendations were required to be made. This necessitated gathering together, arranging and going over a vast mass of papers, in which I had the assistance of Mr. R. Senior-White, with whom I prepared a review of the present state of our knowledge of this subject, read at the Fourth Entomological Meeting. My suggestions for future work on this subject were submitted to Government and endorsed by the Surra Committee which met at Simla on 6th June.

Considerable breeding work has been done with mosquitos, particularly in connection with the fauna of holes in trees. *Stegomyia thomsoni*, *S. albopicta*, *S. gubernatoris* and *S. w-alba* have been found commonly in these situations.

EXPLANATION OF PLATE VIII.

Cosmophila sabulifera.

Fig. 1. Jute plant with larvæ feeding on it, in natural attitudes and sizes.

,, 2. Full-grown larva, magnified.

,, 3. Section of soil showing method of pupation.

,, 4. Pupa, magnified.

,, 5. Moth, natural size, resting attitude.

Figs. 6, 7. Two colour-forms of moth, magnified.

ACRONYCTA SABULIFERA

together with various Culicines. The Tabanid, *Gastroxides ater*, also occurs commonly in tree-holes.

With reference to the role of blood in ovulation in Culicidæ, a large number of dissections has been made of the ovaries of *Stegomyia albopicta*, Skuse; as yet, in none of the mosquitos fed on milk or sugar have the ova been found to be mature, although the mosquitos had mated and lived in captivity for more than three weeks. In view of the fact that I once found an example of *Culex vishnui* sucking an Amatid (Syntomid) moth in Ceylon, trials have been made to try and induce specimens of *Stegomyia* to feed on living Lepidoptera, as well as on reptilian and amphibian hosts, but so far without success.

Mr. S. K. Sen has carried out some observations on the toxicity of certain chemical substances (referred to in Annual Report 1919-20, item 2, p. 102) with reference to the larvæ of *Stegomyia albopicta*. The inquiry owes its origin to a series of papers published by Moore in the *Journal of Agricultural Research* on the subject of interdependence of toxicity and boiling points (or volatility) of certain classes of chemical substances, in the course of which he has attempted to bring out that, generally speaking, in the case of the substances he experimented with, volatility might be considered their toxicity index. It is not possible to enter here into a discussion of this question and of the comparative merits of the various methods of experimentation adopted by different workers, which would be of a controversial nature, involving references to work done by other investigators, notably Freeborn and Atsatt (*Jour. Econ. Entom.*) and Holt (*Lancet*). The following preliminary results were obtained with the larvæ of *Stegomyia albopicta* (for *modus operandi* Annual Report 1919-20, referred to above, may be consulted) [the figures represent average longevity of larva, in minutes]:—

Chloroform, 0; Bromoform, 0; Carbon tetrachloride, 0 (in one instance the maximum longevity was 6 minutes); kerosine, 9; Xylol, 1; Petrol, $4\frac{1}{2}$; Toluene, ?0; Benzine, 0; Ortho-nitro-toluene, 0; Orthotoluidine, 0; Quinoline, not

dead even at the end of 26 minutes, but in one instance the average longevity was 15; Nitrobenzine, 0, but in one instance it was $7\frac{1}{2}$; Aniline, $\frac{1}{2}$; Methyl-aniline, $\frac{1}{2}$; Pyridine, $1\frac{1}{2}$; Acetaldehyde, 2; Formalin, 8; Benzaldehyde, $\frac{1}{2}$; Cinnamic aldehyde, 4; Ethyl acetate, 0; Ethyl benzoate, $\frac{1}{2}$; Amyl acetate, ?$4\frac{1}{2}$; Amyl formate, $\frac{1}{2}$.

Every precaution was taken to prevent the formation of surface films or of solutions, but it was impossible to detect if any had been formed (accidentally or by virtue of physical or chemical properties), nor have the complexities arising out of the relation of these substances to aqueous vapour been taken into consideration. The results are given as they were recorded, and their preliminary character is emphasized.

Some flies, probably *Chrysomyia bezziana*, Villeneuve,* were reared from maggots extracted from wounds in the soft palate of a patient suffering from this form of myiasis in the Pusa Hospital and have been forwarded to Professor Patton for exact determination.

IV. Bees, Lac and Silk.

Bees. No special work with bees has been done except carrying on work on a small scale with *Apis indica*. It was notable this year that *Apis dorsata*, of which a few migrant colonies often visit Pusa for a short time in March, was present in small numbers during the Rains of 1921. Various inquiries regarding Apiculture have been dealt with and improved hives supplied.

Lac. The emergence of the larvæ took place at Pusa on 22nd October 1920 and 27th June 1921, the latter being a late date. There is a great demand for brood-lac, which cannot be met with the present resources at Pusa.

A few small consignments of *Shorea talura* brood-lac were received from Bangalore and placed on different kinds of lac-producing trees at Pusa, but the insects failed to establish themselves.

*Since confirmed by Professor Patton as *C. bezziana*.

Silk. The Sericultural establishment is still on a temporary footing which has been extended during the current year, but it is probable that it will be transferred shortly to the Department of Industries under the Bihar and Orissa Government. In the meantime former lines of work have been continued. Experiments on mongrelization of mulberry silkworm races have been continued and it has been found that first-generation crosses invariably yield about fifty per cent. more silk than the pure races, but in later generations this improvement is not wholly maintained; the multivoltine mongrel races which have been under rearing for the last four years are still yielding about twenty per cent. more silk than the indigenous multivoltine races, from which they were derived, but it is not known whether this improved yield will be reduced in further generations. Feeding experiments have been carried on with leaves of tree, as opposed to bush, mulberry, and it has been confirmed that the former gives a yield of silk superior in quality and quantity to that obtained by use of the latter. Experiments with univoltine silkworms from Bengal, China, Japan and Italy have been continued.

Mulberry silkworm eggs have been distributed to fifty applicants and mulberry cuttings to five applicants. Eri silkworm eggs have been supplied to 92 applicants and castor seeds to three applicants. Eri seed cocoons have been sent to correspondents in Italy, Egypt and England. Show-cases, showing the stages in the growth of the worms and manufacture of silk, have been supplied to three applicants. Silk exhibits, to demonstrate rearing, reeling, spinning and twisting, were sent to Benares Agricultural Exhibition, Lucknow Co-operative Exhibition, and Muzaffarpur and Bihta Agricultural Exhibitions; a silver medal was awarded by the Bihta Exhibition and prizes by the Muzaffarpur Exhibition. Silk exhibits were also supplied to the Government Entomologist, Punjab.

A third (revised) edition of Bulletin No. 39, Instructions for Mulberry Silkworm Rearing, was issued during the year.

Three students completed the full course of training in sericulture and six others received instruction, whilst four others remained under training at the close of the year.

Silk pieces to the value of Rs. 1,777-9-6 were sold and the sale proceeds credited to the Government.

V. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*, *Leucophlebia lineata*, *Polyptychus dentatus*, *Junonia almana*, *Grammodes geometrica*, *Arge luteiventris*, *Sphryracephala hearseiana*, and *Metanastria hyrtaca*. Besides these, many illustrations in black and white, illustrating the life-histories of various insects under rearing in the Insectary or crop-pests, were prepared.

VI. Insect Survey.

Slow but steady progress has been made in additions to, and arrangement and identification of, the collection of insect specimens, which, as specimens are accumulated and worked over by specialists in the various groups, is constantly becoming a more valuable one. As the entomological Staffs in the Provinces are expanded also, there is the more need of a large well-named collection in order to relieve the Provincial workers as far as possible of the systematic work which must go hand-in-hand with the applied work to obtain the best results from the latter. No census of the Pusa collection has been taken for some years but it is estimated to contain rather more than 7,000 named species of Indian insects.

The collection of Hymenoptera is in good order and well named up except for the Chalcidoidea and Braconidæ. During the year small lots of Tenthredinidæ were sent to Mr. Rohwer, Bees to Professor Cockerell and Chalcidoidea to Captain Waterston for identification.

The Coleoptera are in fair order but there is still a large amount of unnamed material to be sorted out, named and incorporated. Specimens of the following have been

received back named by various specialists, to whom our thanks are due, *viz.*, Anthribidæ by Dr. K. Jordan, Staphylinidæ by Dr. M. Cameron, Carabidæ by Mr. H. E. Andrewes, Histeridæ by Mr. G. Lewis, and Scolytidæ by Mr. C. Beeson.

The Lepidoptera are in fair order but many accessions remained to be named up and incorporated. The collection of Microlepidoptera is contained in cabinets and comprises over 700 named Indian species; a few specimens were sent to Mr. E. Meyrick for identification and have been received back named.

The Orthoptera have not been arranged since the late W. F. Kirby identified the earlier collections eleven years ago. Since then a mass of material has accumulated and the whole of the Mantidæ, Blattidæ and unnamed Dermaptera have been sent to Mr. Morgan Hebard, to whom the Phasmidæ, Gryllidæ and Tettigoniadæ will also be sent. Some of the specimens sent to Mr. Kirby have lately been returned named by Mr. B. Uvarov, to whom the Acrydidæ have been sent and the Acrididæ are being sent.

The Neuroptera (*sensu antiquo*) require a good deal of work. The Odonata have been revised and large accessions named by Major Fraser, who is also describing the numerous new forms found in the collection.

The Diptera collections formerly contained in the Entomological and Pathological Entomological collections have now been amalgamated into one series. The Culicidæ have been revised and practically all the unnamed material has been identified by Major S. R. Christophers. Further lots of Nematocera and Brachycera have been received back named by Mr. E. Brunetti, and Professor E. Felt has also dealt with some Cecidomyiadæ. The Tipulidæ have been put together and arranged in a cabinet. The Tabanidæ have been collected together and remounted. The whole collection of Diptera is being gone over, remounted as necessary, and sorted out as far as possible.

The Rhynchota are in fair order, but there is a large accumulation of unnamed material. One box of miscella-

neous Rhynchota was received back named by Mr. W. L. Distant, to whom the unidentified Reduviidæ were sent. The large collection of Heteroptera has been gone over, all scattered specimens brought together and a working basis prepared for a more intensive study of this group. Several consignments of Coccidæ were sent to the Imperial Bureau of Entomology and two identification lists have been received.

Numerous collections of Indian Insects have been received and named as far as possible. These included collections sent by the Forest Research Institute, the Provincial Departments of Agriculture, the Bombay Natural History Society, and by numerous correspondents.

VII. Catalogue of Indian Insects.

The project for the preparation and publication of a catalogue of all described Indian Insects has been approved by Government and considerable progress made during the year. A progress report was submitted to the Fourth Entomological Meeting by the Standing Committee and since then a sample catalogue has been prepared and circulated to the Committee for criticism of details, the lists of the various groups of Orthoptera have been revised, and arrangements made with Lieutenant-Colonel W. H. Evans for the preparation of the catalogue of butterflies. The Psyllidæ, Thysanoptera, Thysanura, Collembola, Zoraptera, and Japygidæ have also been listed. References to current literature have also been supplied to workers on the catalogue.

VIII. Fourth Entomological Meeting.

The Fourth Meeting of Entomological Workers in India was held at Pusa from 7th to 12th February 1921 and attended by over forty members, both professional and amateur, from India and Ceylon, fifty papers on various aspects of Indian Entomology being submitted to the Meeting. A short account of this Meeting was published

in the May (1921) Number of the *Agricultural Journal of India* and a full Report is now in the press.

IX. Programme of work for 1921-22.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees and stored grain. Should the proposals of the Surra Committee be approved, work on the biting flies concerned in the transmission of this disease will also be taken up.

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in lac and bee-keeping will be continued and new insecticides and insecticidal methods tested as occasion arises. Systematic work will be carried out with our resources and the help of specialist correspondents. The catalogue of Indian insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications, either written by the Pusa staff or based on material sent from Pusa, have been actually issued during the year ended 30th June 1921 :—

Andrewes, H. E. . Notes sur les Carabiques orientaux. II. (*Ann. Soc. Ent. Belg.*, LX, pp. 106-111; Sept. 1920.)

,, Notes on Oriental Carabidæ. I. (*Ent. Mo. Mag.*, LVI, pp. 235-240; Oct. 1920.)

,, Papers on Oriental Carabidæ. V. (*Ann. Mag. Nat. Hist.* (9), VI, pp. 493-506; Dec. 1920.)

Cameron, M. . . New species of Staphylinidæ from India. I. (*Ent. Mo. Mag.*, LVI, pp. 145-148, July 1920; *l.c.*, pp. 214-216, Sept. 1920; *l.c.*, pp. 217-220, Oct. 1920.)

Cockerell, T. D. A. . Descriptions and Records of Bees. LXXXIX. (*Ann. Mag. Nat. Hist.* (9), VI, pp. 201-211; Aug. 1920.)

De, M. N. . . . The Pusa experiments on the improvement of Mulberry Silkworms (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 800-808, t. 128; Nov. 1920.)

,, The best method of eliminating Pebrine from Multivoltine Silkworm races in India. (*loc. cit.*, pp. 809-828, t. 129; Nov. 1920.)

,, Instructions for rearing Mulberry Silkworms. (Pusa Bulletin 39; Third (revised) edition.)

Felt, E. P. . . New Indian Gall Midges (Diptera). (*Ind. Agric. Entl. Mem.*, VII, pp. 1-11; Aug. 1920.)

Fletcher, T. Bainbrigge. Insect Life and Insect Pests. (Clouston's *Lessons on Indian Agriculture*, pp. 131-151, ff. 43-47; London, 1920.)

,, Annotated List of Indian Crop-pests. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 33-314, t. 2-8; Nov. 1920.)

,, Life-histories of Indian Microlepidoptera. (*loc. cit.*, pp. 838-857; Dec. 1920.)

,, Hints on collecting and preserving Insects. (*loc. cit.*, pp. 936-974, t. 146-161; Dec. 1920.)

,, Note on a very curious Geometrid larva. (*loc. cit.*, p. 978, t. 162; Dec. 1920.)

,, Indian Epipyropidæ. (*loc. cit.*, pp. 979-982, t. 163; Dec. 1920.)

,, Indian Fossil Insects. (*loc. cit.*, pp. 983-989, t. 164-166; Dec. 1920.)

,, The desirability and practicability of the preparation and publication of a General Catalogue of all described Indian Insects. (*loc. cit.*, pp. 989-999; Dec. 1920.)

,, Note on Plant Imports into India. (*loc. cit.*, pp. 1051-1069, t. 180-182; Dec. 1920.)

Fletcher, T. Bainbrigge. Life-histories of Indian Insects. Microlepidoptera. (*Ind. Agric. Entl. Mem.*, Vol. VI, Nos. 1-9; Jan. 1921.)

,, "Hopping" Pupa of a Curculionid Beetle. (*Journ. Bombay Nat. Hist. Soc.*, XXVII, pp. 407-408, figs.; Jan. 1921.)

,, Agricultural Entomology. (*Ann. Rept. Bd. Sci. Advice, India*, 1919-20, pp. 47-50.) List of Publications on Entomology (*loc. cit.*, pp. 74-100; April 1921.)

,, The Fourth Entomological Meeting. (*Agric. Journ. India*, XVI, pp. 280-286; May 1921.)

Fletcher, T. Bainbrigge, and Ghosh, C. C. . . . Borers in Sugarcane, Rice, etc. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 354-418, t. 23-69; Nov. 1920.)

,, The preservation of wood against Termites. (*loc. cit.*, pp. 705-712; Nov. 1920.)

,, Stored Grain Pests. (*loc. cit.*, pp. 712-758, t. 100-124; Nov. 1920.)

,, Notes on rearing Insects in hot countries. (*loc. cit.*, pp. 875-892, t. 131-138; Dec. 1920.)

Fletcher, T. Bainbrigge, and Misra, C. S. Cotton Bollworms in India. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 443-470, t. 79; Nov. 1920.)

Fraser, F. C. . . Description of a Rhinocyphine larva from Shillong. (*Ind. Agric. Entl. Mem.* VII, No. 2; Aug. 1920.)

Ghosh, C. C. . . Bee-keeping in India. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 770-782, t. 125; Nov. 1920.)

,, Suggestions regarding publication of communications on Indian Insects. (*loc. cit.*, pp. 1034-1042; Dec. 1920.)

,, Some aspects of Economic Entomology in India. (*loc. cit.*, pp. 1072-1080; Dec. 1920.)

Meyrick, E. . . Exotic Microlepidoptera, Vol. II, pts. 12 (Dec. 1920) and 13 (Jan. 1921).

Misra, C. S. . . The Rice Leaf-hoppers. (*Ind. Agric. Entl. Mem.*, V, No. 5; Aug. 1920.)

Misra, C. S. . . Some Indian economic Aleyrodidæ. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 418-433, t. 70-77; Nov. 1920.)

,, The Rice Leaf-hoppers. (*loc. cit.*, pp. 433-443, t. 78; Nov. 1920.)

,, Some Pests of Cotton in North Bihar. (*loc. cit.*, pp. 547-562, t. 93-97; Nov. 1920.)

,, Index to Indian Fruit-Pests. (*loc. cit.*, pp. 564-596; Nov. 1920.)

,, Tukra Disease of Mulberry. (*loc. cit.*, pp. 610-618, t. 98; Nov. 1920.)

,, Lac-culture in India. (*loc. cit.*, pp. 782-800, t. 126-127; Nov. 1920.)

,, The "American Blight" or the "Woolly Aphis," *Eriosoma* (*Schizoneura*) *lanigera*, Hausmann. (*Agric. Journ. India*, XV, pp. 627-635, t. 38-42; Nov. 1920.)

Ramachandra Rao. Y. *Lantana* Insects in India, being the Report of an Inquiry into the efficiency of indigenous Insect pests as a check to the spread of *Lantana* in India. (*Ind. Agric. Entl. Mem.*, Vol. V., No. 6; July 1920.)

,, *Lantana* Insects in India. (*Report Proc. Third Entl. Meeting, Pusa 1919*, pp. 671-680; Nov. 1920.)

Rohwer, S. A. . . Notes on Sawflies, with descriptions of new Genera and Species. (*Proc. U. S. Nat. Mus.*, LIX, 83-109; 28 June 1921.)

Uvarov, B. P. . . Records and Descriptions of Indian Acrididæ (Orthoptera). (*Ann. Mag. Nat. Hist.* (9), VII, pp. 480-509; June 1920.)

In addition to the foregoing, the following publications were in the press at the close of the year:—

Dutt, G. R. . . Three new Wasps from India. (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 5.)

,, An interesting example of Gynandromorphism in *Megachile bicolor*, Fb. (*Report Proc. Fourth Entl. Meeting, Pusa 1921.*)

,, *Gracillaria soyella*, Dev., and its parasite, *Asympiesiella india*, Gir. (*loc. cit.*)

Felt, E. P. . . New Indian Gall Midges (Itonididæ). (*Ind. Agric. Entl. Mem.*, Vol. VII, No 4.)

Fletcher, T. Bainbrigge.	Additions and Corrections to the List of Indian Crop-pests. (*Rep. Proc. Fourth Entl. Meeting, Pusa 1921.*)
,,	Traps for Mosquitos. (*loc. cit.*)
,,	Note on the Oviposition of *Gynacantha Bainbrigge*. (*loc. cit.*)
,,	Koenig's Paper on South Indian Termites. (*loc. cit.*)
,,	Setting Without Boards. (*loc. cit.*)
Fletcher, T. Bainbrigge, and Senior-White, R. . .	Surra and Biting Flies: a Review. (*loc. cit.*)
Ghosh, C. C. . .	Supplementary observations on Borers in Sugarcane, Rice, etc. (*loc. cit.*)
Howlett, F. M. . .	Protective movements and range of vision in platypezid Flies. (*loc. cit.*)
,,	The practical application of Insect Psychology. (*loc. cit.*)
Misra, C. S. . .	Oxycarenus lætus; the Dusky Cotton Bug. (*loc. cit.*)
,,	*Anatrachyntis falcatella*, Stt. (*loc. cit.*)
,,	Determination of emergence of larvæ from examination of the ovaries of Lac Insects. (*loc. cit.*)
Patel, P. G. . .	Note on the life-history of *Culicoides oxystoma*, with some remarks on the early stages of *Ceratopogon*. (*loc. cit.*)
Sen, S. K. . .	Life-histories of Indian Insects. Diptera: *Sphryracephala hearseiana*, Westw. (*Ind. Agric. Entl. Mem.*, Vol. VII, No. 6.)
,,	A note on the effects of mercurous chloride on Culicid larvæ. (*Report. Proc. Fourth Entl. Meeting, Pusa 1921.*)
,,	Notes on the life-history of two species of Celyphidæ. (*loc. cit.*)
Senior-White, R., and Sen, S. K.	Further notes on the occurrence of Coleoptera in the human intestine. (*loc. cit.*)
Sharma, H. N. .	A preliminary note on the action of acids, salts and alkalies on the development of Culicid eggs and larvæ. (*loc. cit.*)
Sharma, H. N., and Sen, S. K.	Oviposition in Culicidæ. (*loc. cit.*)

REPORT OF THE PROTOZOOLOGIST.

(A. Pringle Jameson, D.Sc.)

During the past year considerable progress has been made in the investigation of silkworm diseases in India, and it is hoped that by October next sufficient material will have been collected for a report on the subject to be published. In view of the early completion of the inquiry a detailed yearly report is perhaps not necessary, so that a short summary of the work done may suffice.

The most important feature of the year's work has been the census of silkworm diseases which has been and is still being conducted. One would have thought that this would have been done in the past but I have been able to find no records of such a piece of work—only vague statements of opinions as to the amount of disease present. The material is being got chiefly from Bengal, but other silk-rearing provinces have also been sending samples. I am especially indebted to Mr. P. C. Chaudhury, Officiating Deputy Director of Sericulture, Bengal, for his assistance in getting me cocoons for examination. The results of the census are so far very interesting. Worms reared from village seed—that is to say, from eggs which have not been selected by microscopic examination—are found to be full of disease. Indeed, in most cases every specimen examined is very heavily infected with pebrine. Worms reared in villages from seed supplied by the Government nurseries are singularly free from pebrine, and nursery seed itself is also reasonably good. With regard to diseases other than pebrine there is nothing much to remark. Flacherie, so called, is found in a considerable number of cases, but this disease, which is being studied also, is evidently in no way comparable as regards its lethal qualities with flacherie in univoltine worms. It does not seem to be of very great importance in India. Muscardine has not been found but the "Fly" is very destructive.

Another fruitful line of work has been the experiments on infection conducted in the houses of village rearers in Bengal. Here again I wish to express my thanks to Mr. Chaudhury for the assistance which he and his staff at the Berhampore Central Nursery have rendered me. It is extremely important to find out how much infection is picked up in a rearer's house if he is supplied with absolutely disease-free seed. So far the results got have confirmed the results of my previous experiments conducted in artificially infected houses, namely, that relatively little infection is acquired in this way. Thus good seed is above all important.

Experiments are being carried on at Kalimpong, Berhampore and Pusa to try to arrive at some conclusion regarding hill amelioration of seed. These experiments are not yet sufficiently far advanced to give any definite results as the station in Kalimpong was started only in March.

Work on the life-history of *Nosema bombycis*, the parasite causing pebrine, has been carried on especially with a view to finding out the details of the methods of infection. Disinfection experiments have been continued and an attempt has been made to ascertain how long infected buildings remain infective.

Of the other diseases from which silkworms suffer the only one which is at all common—if we except the "Fly" pest—is a disease of the flacherie type. Examples of this have been carefully studied, especially a bad outbreak among the Muga worms in the Jorhat District of Assam in March. The results are too complex to go into here, but it may be said that they lead one to the view held by some Italian and Japanese workers that flacherie is not an infectious disease under ordinary conditions. Certain bacteria may or may not be associated with it, but the trouble is almost certainly started by bad weather conditions, so that the control of diseases of this type will be extremely difficult.

Assam was visited in March in connection with the outbreak of disease among the Muga worms. Bengal was visited in April and again in May in connection with the experiments being conducted there. Kashmir was visited in May and specimens of disease among univoltine worms were collected and information obtained as to the possibilities of rearing univoltine worms on a large scale in suitable districts in India.

Programme of work for 1921-22.

As has been said, the inquiry is nearing completion. Work will be carried on along the above lines until about October when it is hoped that sufficient data will have been got together to enable a report to be published.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Charge and training.

Charge. The writer held the post of Imperial Agriculturist up to the 22nd September, 1920, when he proceeded to England on deputation to make arrangements for motor tractor trials in India, and returned on the 28th of February, 1921. During the time of his absence the post of Imperial Agriculturist was held by Mr. Wynne Sayer, Secretary, Sugar Bureau.

The Society of Motor Manufacturers and Traders agreed to run trials in India of a most comprehensive nature, but it was found impossible, owing to the financial stringency, to carry out these trials.

Training. The proposed course of post-graduate training in agriculture has not yet been started. Buildings and staff are expected to be available shortly for this purpose. In the meantime only a few men are under training on the farm in practical agriculture.

II. Pusa Farm.

Details regarding the Farm and Experiment Area have been given in former annual reports. The general object of the farm, which comprises 450 acres of arable land, is to provide "feed" for the pedigree herd of cattle. It is worked on thoroughly practical lines and forms a demonstration in economical and practical working of a large Indian agricultural property. The Experiment Area is quite independent and the various experiments are run in collaboration with other Sections at Pusa.

The Season. Rainfall from June 1920 till May 1921 was 44·33″ as against 32·73″ last year. The monsoon was late in beginning and there was very heavy rainfall in September. The October rains were, however, very poor and consequently the *rabi* crop was light. The *kharif*

maize crop was extremely good, but the maize kept for grain was badly laid by heavy rains.

Rotation. The following are the details of the rotation carried out in the non-experiment area :—

	1st Year	2nd Year	3rd Year
Monsoon crop (*Kharif*) .	Maize for silage and fodder	Maize for corn	Pulse green crop
Winter crop (*Rabi*) . . .	Oats . .	*Rahar* (*Cajanus indicus*)	Oats

This rotation has been running long enough to show its suitability for the Pusa Estate. It has, however, been criticised on the ground that it is too exhaustive. This, however, is not borne out by the results of the maize crop the condition of which is an excellent gauge of fertility. This crop shows no signs of suffering from a decrease of fertility. When however the winter rains fail, the cold weather grain crops are often deficient in straw.

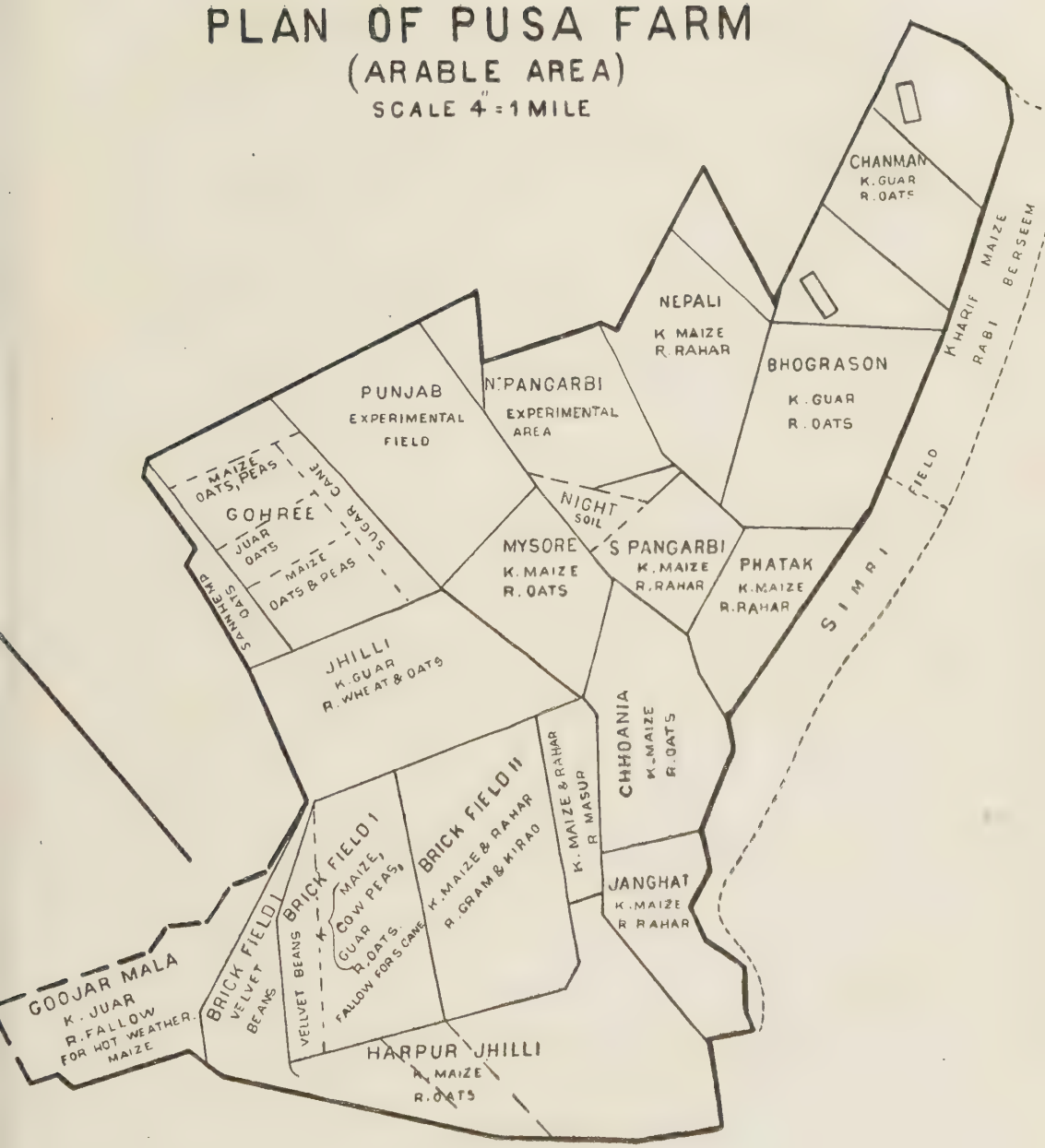
This rotation entails very heavy work at two periods of the year, but with the steam ploughing tackle and tractors no difficulty has been experienced in keeping the cultivation operations up to time. The weak point of the rotation is that it yields very little fresh "feed" for the cattle from January until May, but this has been got over by preparing a piece of land for irrigation. Water is pumped from the river and green fodder is available when most required, *viz.*, during the hot weather. This has made a very large difference in the total yield of milk.

Crops during the year. Maize cut green for silage in Mysore field gave over 200 maunds per acre, and 10 acres of *jowar* (*Andropogon Sorghum*) averaged 400 maunds per acre. The maize for grain did not yield as well as usual owing to the plants being beaten down by heavy rains—the best yield was 11 maunds grain per acre from the Nepali field while the *rahar* or *tur* which remains as a *rabi* crop after the maize is cut out also yielded badly. The best yield was 8 maunds an acre from Janghat field

PLAN OF PUSA FARM

(ARABLE AREA)

SCALE 4" = 1 MILE



while the average yield on the whole was only 5 maunds an acre.

Pulse crops. The pulse crops are sown in the *kharif* and are either fed green to the cattle on the land or ploughed in for green-manuring. The most suitable pulses are *guar* (*Cyamopsis psoralioides*), velvet beans, and maize and cowpeas mixed. On an average one acre is sufficient for about 100 cattle per day.

Oats. The oats crop was all over normal; the best yield was 19·71 maunds an acre. The small area of Federation wheat yielded 18 maunds an acre.

Sugarcanes. The following varieties of canes were grown under the supervision of Mr. Wynne Sayer, Secretary, Sugar Bureau :—

(*a*) *Java canes.*

Java 33 A	Java 247
Java 36	Java 213
Java 139	

(*b*) *Thick canes.*

Purple Mauritius	Sathi 131
D. 99 American	D. 1135 from Sepaya

(*c*) *Thick indigenous canes.*

Reora	Mungo
Yuba	Kuswar
Saretha	Maneria

The following canes were specially selected :—

	Sucrose %
Co 210	13·61
Co 213	14·00
Co 214	17·51
Co 220	15·24
Co 221	15·80
Co 224	14·56
Co 225	18·71
Co 227	14·87
Co 228	15·58
Co 231	16·34
Co 232	17·47
Co 233	15·13

The indigenous varieties gave the following results :—

	Sucrose %
Yuba	14·06
Saretha	16·67
Mungo	15·99
Kuswar	16·48
Maneria	14·36
Reora	14·60

III. Permanent Experiments.

These are continued as before in the two fields specially laid out for the purpose.

(*a*) The permanent manurial and rotational experiments were continued as before in accordance with the recommendations of a Sub-Committee appointed by the Board of Agriculture held at Pusa in December 1919.

Series I. The object of this series is to determine the specific effect on soil fertility of the more important organic and chemical manures applied alone and in various combinations on a two years' four-course rotation.

Series II. The object of this series is to determine how far soil fertility is affected by growing in rotation leguminous crops (1) removed from the land and (2) returned to the land in the shape of green manure. It is complementary to Series I in-as-much as the results obtained will give an indication of how far legumes can replace manures in rotation.

(*b*) The green-manuring experimental plots designed in collaboration with the Imperial Agricultural Bacteriologist were continued for the purpose of testing residues. This experiment was started in 1917-18 and ended in 1920-21.

(*c*) The experiments in collaboration with the Imperial Mycologist regarding a method of dealing with die-back disease in chillies were continued.

(*d*) Twenty varieties of wheat were tried in the year under report :

2 varieties Pusa, Federation Soft, Federation Hard,
2 varieties U. P., 10 varieties Punjab,
4 varieties Sind.

All Punjab and Sind varieties were found badly rusted and one U. P. also, Mozaffernagar White. The Pusa varieties and Federation Hard and Soft and one U. P. variety (Cawnpore 13) were rust-resistant.

The best results were obtained from :—

(1) Federation Soft, (2) Federation Hard, (3) Pusa 4, (4) Pusa 12, (5) Cawnpore 13.

(*e*) The experiments for comparing the economic value of the common leguminous crops were continued. There are two series of plots in this experiment. One series is grown with *kharif* pulses to produce green fodder in the *kharif* and is followed by winter pulses for grain in the *rabi* season; the second series is for testing grain outturn of both *kharif* and *rabi* pulses.

The table below shows this year's results :—

TABLE I.

Showing outturn in a series grown with kharif *pulses to produce green fodder.*

Kharif pulses	Green fodder per acre in lb.
Guar (*Cyamopsis psoralioides*)	6,898
Math (*Phaseolus aconitifolius*)	10,840
Urid (*Phaseolus radiatus*)	5,502
Val (*Dolichos lablab*)	1,971
Florida beggar weed	3,285
Florida velvet bean	12,113
Soybeans	5,913
Cowpeas	10,183

Series A. Among the *kharif* pulses used for green fodder all are good in feeding value, but in the outturn Florida velvet bean is the highest, *math* takes the second

place and then cowpeas. The Florida beggar weed and *val* are poor yielders and perhaps not suitable for Bihar.

Among *rabi* pulses which are followed by the above *kharif* pulses, gram stands best in yield of grain, next comes lentils and last peas.

Series B. Among *kharif* pulses for grain, *math* turned out best.

(*f*) Experiments with Java and Sumatrana indigo conducted in collaboration with the Indigo Research Chemist and the Imperial Agricultural Bacteriologist, and the wilt disease experiments in collaboration with the Imperial Mycologist and the Fibre Expert to the Government of Bengal were continued. These experiments will last over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Mycologist in their respective reports.

As in past years crops were grown in North Pangarbi field for the other Sections.

(*g*) *Phosphate experiments.* These experiments, in collaboration with the Imperial Agricultural Chemist, dealt with sodium phosphate, sodium pyrophosphate and sodium metaphosphate prepared in the laboratory and tried on the maize crop in combination with sulphate of ammonia, against commercial superphosphate, and then the following oats crop to estimate the residual effect. Results will be published after an average of several years' figures has been obtained.

IV. Implements and Machinery.

Steam Ploughing Tackle. The set of tackle consisting of two single cylinder "K" class Fowler engines with steel wire rope and four furrow anti-balance gang plough, a disc harrow, a grubber, a zigzag harrow and Crosskill roller, worked during the year for 131·65 days of 10 actual working hours each. The engines were also used for silage cutting and for threshing oats in seasons when there was no cultivation work to be done on the farm.

The cost of the set in 1913 was as follows :—

	Rs.
Two engines with steel cables	30,000
Plough	3,700
Disc harrow	3,625
Grubber	3,227
Zigzag harrow and roller	2,925
TOTAL .	43,477

TABLE II.

Showing cost of working the Steam Tackle for five seasons.

Particulars	1916-17	1917-18	1918-19	1919-20	1920-21
	No. of working days 151	No. of working days 121	No. of working days 145	No. of working days 126	No. of working days 131
	Rs.	Rs.	Rs.	Rs.	Rs.
Labour	1,233	940	934	1,200	1,450
Coal	1,788	1,424	1,656	1,623	2,140
Oil	300	315	482	633	588
Miscellaneous stores, etc., and renewals	713	3,419	1,064	1,196	1,746
TOTAL	4,034	6,098	4,136	4,652	5,924

TABLE III.

Showing the above costs divided into following operations per acre for five seasons.

Particulars	1916-17			1917-18			1918-19			1919-20			1920-21		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work
	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres
Ploughing . . .	267	4·3	7	170·5	9·2	7	373·5	3·9	7·5	404·5	4·8	7·5	445	6·0	7·5
Disc harrowing . .	498	2·0	18	821·5	3·0	20	605·5	1·7	16·5	582·0	1·7	20·5	633	2·5	17·5
Grubbing . . .	1,080	1·4	25	616·0	4·3	26	668·0	1·4	20·5	488·0	1·6	22·0	480	2·0	22·0
Zigzag harrowing . .	41	0·9	27	11·0	2·2	..	..	..	..	..	..	..	..	..	..
Rolling	320	1·3	22	173·0	3·9	22	540·0	1·3	21·0	533·0	1·6	23·0	386	1·8	25·0
TOTAL	2,206	..	..	1,792	..	..	2.187	..	..	2,007·5	..	..	1,944	..	..

Motor Tractors. During the season, Fordson, Austin and Cletrac tractors have been used on the farm. Detailed accounts of cost of working have been kept, but these are too lengthy for publication in the present report. In general it may be stated that it is necessary to avoid putting light weight tractors on heavy work as this is certain to cause ultimate breakdown. They are, however, very useful for subsidiary operations but the cost of deep ploughing with tractors, as compared with cost with steam tackle, has been found to be high. The cost of renewals and spare parts and general depreciation, which can be estimated accurately only after a number of years' working, will certainly be considerable.

When it is possible to hold motor tractor trials on an adequate scale in India, this branch of agricultural machinery will undoubtedly receive a considerable impetus. At present it is not possible to give advice to enquirers with any degree of confidence.

The note made by the writer in the last annual report regarding the unsatisfactory state of agricultural machinery trade in India unfortunately still holds good. It is still extremely difficult to get spare parts for a number of makes of tractors.

Some of the more pressing mechanical problems of the farm have received attention during the current year, *e.g.*, the production of a wheat thresher suitable for zemindari conditions in North-West India and also the possibility of the practical use of self-binders for harvesting grain crop with the use of tractors. Plate IX shows the work of a pair of binders in the oats crop in Pusa.

V. Pedigree Dairy Herd.

The herd continues to progress satisfactorily. There are two divisions: —

(*a*) A pure bred Montgomery or Sanhiwal herd.
(*b*) A cross-bred herd obtained by crossing the poorer Montgomery cows with Ayrshire bulls.

THE "SELF-BINDERS" WORKING IN A LIGHT CROP OF OATS.

THREE BEST CROSS-BRED COWS OF THE PUSA HERD.

PLATE X.

(*a*) **The Montgomery Herd.** This numbers 254 head. During the year under report the average milk yield of the Montgomery cows was 3,787 lb. of milk per head. The quality of the herd is rapidly appreciating and the figure of milk yield now attained is a very good one. It is expected to get the average yield well over 4,000 lb. per head in the course of a year or two.

(*b*) **Cross-Bred Herd.** The cross-bred herd now numbers 111 head. The average yield per cross-bred cow during the year was 6,105 lb. of milk.

The following table gives details of the milk yield during 1920-21 :—

TABLE IV.

Showing milk yield of Pusa herd during 1920-21.

Month	Cross-bred cows		Montgomery cows milked with calf		Montgomery cows milked without calf		Remarks
	No. of cows in milk	Yield in lb.	No. of cows in milk	Yield in lb.	No. of cows in milk	Yield in lb.	
July 1920 . .	23	11,252	33	12,417	13	3,808	
August 1920 .	25	11,868	36	12,657	12	3,356	
September 1920 .	25	10,283	43	13,734	13	3,470	
October 1920 .	24	8,752	39	12,175	13	2,684	
November 1920 .	23	7,652	38	10,310	12	2,019	Average number of cross-bred cows in milk during the year 24. Average number of Montgomery cows in milk during the year 60.
December 1920 .	23	9,456	39	12,761	14	3,637	
January 1921 .	21	10,239	39	11,008	17	5,510	
February 1921 .	20	10,790	40	13,018	27	7,825	
March 1921 . .	24	16,032	40	14,725	32	10,748	
April 1921 . .	27	17,340	39	13,605	36	12,182	
May 1921 . .	27	17,204	38	11,867	37	12,241	
June* 1921 . .	24	14,426	36	10,046	35	11,436	
	24	1,45,294	38	1,48,323	22	78,916	

* Whole herd attacked by "foot and mouth" disease.

"Alibi," the best cross-bred cow (Plate X), completed her third lactation during the year under report and gave 9,722 lb. of milk in 304 days. She started her fourth lactation after being dried off for two months. This is not yet

complete but she has given 5,020 lb. in 103 days and so should go well over 10,000 lb. This cow since the day of her first calving has given a daily average of $2\frac{1}{10}$ gallons milk including her dry periods. The highest yield in one day was 2 lb. short of 6 gallons.

These figures are very significant in view of the interest which has been recently evinced in dairying in India. It is becoming increasingly difficult to buy good milch cows, and thus the importance of cross-breeding work to increase rapidly the capacity of the Indian strains is manifest.

The accommodation at Pusa farm for the pedigree herd has now reached a limit. The herd is very cheaply maintained as nothing is bought in except oil-cake. It will be necessary to reduce considerably the number of young stock or to find accommodation for them elsewhere. The cross-breeding work is now at a very interesting stage as the first lot of cross-cross heifers, *i.e.*, the progeny of cross-bred cows and cross-bred bulls, and also a number of $\frac{1}{4}$-bred and $\frac{3}{4}$-bred heifers, will shortly come into milk, and it will be possible to judge as to the most profitable lines of selection. It may be found that the strain of $\frac{3}{4}$-Indian bred and $\frac{1}{4}$-Ayrshire bred carefully selected will give the most promising type of animal for Indian dairy factory work.

VI. Sales.

Surplus stock was sold during the year at auction and privately and realized about Rs. 8,000.

VII. Staff.

The staff of the Agricultural Section, though very short-handed, worked with great zeal during the year.

VIII. Programme of work for 1921-22.

Major.

I. Assistance to the various Agricultural Departments.

II. Practical treatment of the Pusa farm with special

reference to suitable modern machinery and the economic results thereof.

III. Practical treatment of the pedigree dairy herd and the fixing of a cross-bred type of milk animal.

IV. Experiment work in collaboration with the various scientific Sections at Pusa as mentioned in the various sectional reports.

V. Rotation and fertility experiments on a field scale and the trial and acclimatization of new crops.

VI. Demonstrations and sales at Pusa.

Minor.

VII. General advisory work of an agricultural nature.

REPORT OF THE IMPERIAL DAIRY EXPERT.

I.

(W. Smith.)

I took over the duties of this appointment on 1st May, 1920, and up to the date of my proceeding on sick leave on 6th January, 1921, the work done may be summarized as follows:—

(1) At the request of the Superintendent, Palace Dairy, Baroda, a complete specification of pasteurizing plant to deal with 4,000 lb. milk per day was furnished, together with detailed information concerning working, cost of various methods of pasteurization, etc. Later on in the year, by request of the Director of Agriculture, Baroda State, I visited Baroda, inspected various suggested sites for a proposed model dairy farm, and advised as to their suitability or otherwise. After this visit, a complete scheme for the establishment of a model dairy at Baroda, with building plans, machinery specifications, live stock lists, and a general explanatory statement was submitted to the Director of Agriculture, Baroda.

(2) Early in August 1920, at the request of the Director of Commerce and Industry, Hyderabad State, I visited Hyderabad and there examined and advised concerning a number of proposed sites for a large dairy farm to supply the city of Hyderabad with fresh milk. During this visit the President of the Council, the Member for Commerce and Industry, and other State officials were interviewed, and, on my return to headquarters, a complete dairy scheme with building plans, machinery specifications, live stock lists, lists of establishment, estimated profit and loss accounts, and general explanatory statement was submitted, and advice given to the Director of Commerce and Industry, Hyderabad.

(3) Whilst at Hyderabad, the privately owned dairy of Mr. Maksud Ahmed at Habshighuda was inspected and advice given as to the development of his dairy business.

(4) Arrangements were made to visit Dewas and Jodhpur States during the cold weather of 1920-21 *re* the establishment of dairy farms there, but owing to my leaving India on sick leave these proposed visits were postponed.

(5) At the request of the Live Stock Expert, Mysore State, detailed plans of new dairy buildings for the Palace Dairy of His Highness the Maharaja were supplied, and on the invitation of the Director of Agriculture, Mysore, I attended at the annual live stock show at Bangalore and acted as judge of the milch cattle classes. Some very fine animals were exhibited at this show, and the entries in some of the classes were very numerous. In October I selected and shipped from Karachi 30 specially well bred Sindhi cows to form the nucleous of a pure bred Sindhi herd for His Highness the Maharaja of Mysore.

(6) A complete scheme with building plans, machinery specifications, live stock lists, and general instructions for the establishment of a model demonstration dairy farm to be attached to the Agricultural College was submitted to the Director of Agriculture, Burma, which province I had arranged to visit in the cold weather.

(7) Early in July, I attended a conference at Poona between representatives of the Bombay Agricultural Department and the military farm authorities concerning the establishment of a dairy school at the military dairy farm, Kirkee. At this conference a scheme for working such a dairy college was drawn up suitable for all concerned, and plans showing the necessary alterations to the existing military dairy buildings at Kirkee as well as detailed specifications of the extra plant and fittings required were furnished by my office.

(8) Arrangements were made with the Director of Agriculture, Bengal, to take over and utilize a Holstein bull gifted to this country from the United States of America. In October a consignment of eight Sindhi cows and two bulls were purchased at Karachi and railed to Rangpur for the Bengal Agricultural Department. Arrangements

to visit Bengal and advise the Director of Agriculture were postponed owing to sick leave.

(9) In accordance with the instructions of the Agricultural Adviser to the Government of India, a note was written concerning the working of the dairy farm at the Imperial Bacteriological Institute, Muktesar, and suggestions made with a view to avoid future trading losses there.

(10) Plans of a proposed new cattle shed were submitted to the Director of the Agricultural Research Institute, Pusa, at his request.

(11) At the request of the Chief Commissioner of Assam I had arranged to visit Shillong to advise on the milk supply of that station, but was unable to do so owing to illness.

(12) Early in July I had two interviews in Simla with the Director of Agriculture, Punjab, concerning proposed cattle-breeding experiments in that province. I visited the military dairy farms at Bangalore and Wellington where similar experimental work to that proposed for the Punjab is now being carried on by the Madras Government. As the result of this visit complete details of the work now being done by the Madras Agricultural Department at the Bangalore military dairy farm were furnished to the Director of Agriculture, Punjab, with a view to his instituting similar experiments at the military dairy farm, Amballa. Information was supplied to the Director of Agriculture, Punjab, as to the number of bulls suitable for distribution obtainable from military farms.

(13) I interviewed the Director of Agriculture, Madras, and obtained his permission to hand over details of the Bangalore experiments to the Punjab Government. I also advised him generally concerning the purchase of Nellore cattle, and subsequently at the request of the Deputy Director of Agriculture for Live Stock, Madras, gave written advice concerning the purchase of cattle for Jamaica, etc.

(14) Correspondence passed between the Kharagpur Station Committee and my office concerning the establish-

ment of a model dairy farm at Kharagpur to provide milk for some 15,000 persons. At the suggestion of the President of this Committee, I visited Kharagpur, examined the proposed site for the dairy farm and later on submitted a complete scheme for the establishment of a suitable dairy with building plans, machinery specifications, live stock lists, lists of establishment, and estimated trading accounts for the first three years' working.

(15) Arrangements were made whereby specially selected men of the backward hill tribes in Bihar and Orissa could be sent to the military dairy farm, Jubbulpore, and there taught the best methods of milking and handling milch cows.

(16) In October, 6 Sindhi cows and 2 bulls were purchased and despatched from Karachi for the Prisons Department, Bihar and Orissa, and written advice was given to the Director of Agriculture of that province concerning the teaching of animal husbandry and dairying to senior students.

(17) Advice was given to the Municipal Commissioner, Bombay, concerning the appointment of a special milk officer for the city of Bombay, and the general question of milk supply, control, and improvement was discussed with this officer in Bombay.

(18) A complete scheme including building plans, machinery specifications, live stock and establishment lists for the establishment of a model dairy at the Veterinary College, Lahore, was drawn up and sent to the Chief Superintendent, Civil Veterinary Department, Lahore.

(19) Enquiries for technical dairy information were received from Mr. B. Chitty, Madras; the Bishop of Dornakal, Hyderabad; Mr. Ghanshamdas Dharamdas, Hyderabad, Sind; Miss Sinclair, Medical Mission, Khulna; the Manager, Sir Daniel Hamilton's Zemindary, Bengal; Mr. M. Shariff, Purnea; Mr. M. C. Joshni, Ahmedabad; Mr. Karan Chand, Amritsar; Manager, Government Dairy, Sukkur; Mr. A. Osaid, Risalpur; Mr. C. E. Laksminarasinha, Vizianagram; The Ahmedabad Cattle Farm and

Industrial Company; Mr. T. B. Singh, Jaipur; etc., and in each case all possible information and advice was given.

(20) Complete building plans and machinery specifications, together with an explanatory statement, were forwarded to the Infants and Public Milk Supply Co., Ltd., for the establishment of a town dairy depôt in the city of Bombay.

(21) At the request of the Town Administrator, Jamshedpur, arrangements were made for the purchase in Scotland and the shipping to India of two pedigreed bulls for the dairy farm of the Tata Iron and Steel Co., Ltd.

(22) On the invitation of the Honorary Secretary, Calcutta Pinjrapole Society, I visited Calcutta and inspected the Pinjrapole maintained by this society. At my suggestion the society purchased a wagon of Sindhi bulls which I selected and railed to them from Karachi. General advice was given to the Secretary, regarding the development of dairying in connection with their cattle-salving operations.

(23) Plans of a suitable cattle shed for eighteen cattle were submitted to Raja Narendranath of Lahore.

(24) I visited Bombay on two occasions in company with Mr. E. J. Bruen, Deputy Director of Agriculture for Live Stock, Bombay, to meet the Hon'ble Mr. Purshotamdas Thakurdas, C.I.E., and his colleagues, and to advise them concerning the starting of a large cattle-breeding and dairy farm. General advice concerning the launching of such a project was given, and the services of an experienced manager to do the preliminary work were secured for this group. During these visits to Bombay, Mr. Bruen and myself had interviews with Lieutenant Patwardhan of the Royal Air Force who was anxious to float a company for the supply of milk to Bombay on modern business lines. After some correspondence and a number of interviews with Lieutenant Patwardhan, Mr. Bruen attended at my office and a complete scheme for the establishment of a large dairy farm at Talegaon was sent to Lieutenant Patwardhan over our joint signatures. This scheme

included complete building plans, machinery specifications, lists of live stock and establishment, estimated profit and loss accounts for three years' working, estimates of capital expenditure, lists of buildings, and a general explanatory statement, the total involving a capital of over Rs. 20,00,000.

(25) Messrs. Gowardhan Dass & Co. of Lahore applied for technical information concerning the establishment of a modern dairy farm, with butter, cheese, and casein factory, and a complete scheme including building plans, machinery specifications, and all other information necessary was sent to them, along with advice *re* the selection of a manager and the general working of such a concern.

(26) The Goraksha Mundal, Ltd., a new company floated in Calcutta, applied for technical information, and, after correspondence, a complete dairy scheme was submitted to this firm, including building plans, machinery specifications, lists of buildings and live stock, estimated profit and loss accounts, etc. This company were also advised concerning the appointment of a manager. I interviewed the promoter and principal Director at Bombay, prior to my departure for England in January 1921.

(27) In company with the Agricultural Adviser to Government I visited the experimental farm at Gurdaspur and the Agricultural College at Lyallpur, Punjab. At the latter place, I had the opportunity of addressing the college students on the importance of cattle-breeding and dairying interests in Indian agriculture.

(28) Throughout the period under review, I had frequent interviews with the Director of Military Farms at Army Headquarters regarding questions affecting the working of military dairies in India, and when at Karachi in October and November I selected over 100 animals for the Assistant Directors of Military Dairy Farms in Northern and Southern Circles.

(29) Information relative to the milking qualities of various Indian breeds of cows and buffaloes, plans of dairy

buildings, photos of cattle, etc., were supplied to the United States Department of Agriculture, Island of Guam Ladrones.

(30) The foregoing brief record will show that a wide and general interest in dairying exists in India, and clearly indicates the great necessity for the immediate establishment of the dairy schools at Lucknow and Poona already sanctioned by the Secretary of State. Without trained men the dairy industry can make no headway. The dairy training now being given at some of the agricultural colleges may be quite suitable for men taking general agriculture, but it will not do for those who want to specialize in dairying and who are to be dairy factory managers or dairy farmers. In fact, for such men, the dairy instruction now given in Indian agricultural colleges provides just that little knowledge which is a dangerous thing. There is no objection to a dairy school being attached to an agricultural college, but the instruction given must be by trained and experienced dairy specialists with modern plant, efficient herds, and up-to-date buildings.

To attempt to develop the dairy industry by advising men to start concerns without knowing where the men to work them are to come from is putting the cart before the horse.

The crying need of this industry is efficient and sufficient dairy education. Without this, no real progress can be made.

II.

(G. S. Henderson, N.D.A., N.D.D.)

The foregoing report gives an account of the work of Mr. Smith up to the time of his proceeding on sick leave. The charge of his office was made over temporarily to Mr. Wynne Sayer, B.A., Officiating Imperial Agriculturist and Secretary, Sugar Bureau, who officiated in the post until my return from deputation duty in England on the 28th of February. I was appointed to act as Imperial Dairy Expert in addition to my own duties with effect from 1st March, 1921.

The work of the remainder of the year may be briefly described as follows :—

(1) At the request of the Director of Agriculture, Bengal, two first class grey Thar Parkar bulls were supplied to the Superintendent, Government Cattle Farm, Rangpur, by purchase from Karachi District; also two Montgomery bulls were supplied to the District Board, Palamau, one bull to Superintendent, Gaya Jail, and one truck load of Sindhi cows to Farm Superintendent, Kanke, Ranchi, at the request of the Director of Agriculture, Bihar and Orissa, by purchase from Karachi District.

(2) The gift of one Holstein bull from the United States of America referred to in the above report by Mr. Smith was from Mr. Alexander Phillips, Second Vice-President, Bemis Brothers Bag Company, 40, Central Street, Boston, United States of America, who on a visit to India in May 1920 offered to present a young pedigree bull (Holstein) to the Agricultural Department and land it at any port in India free of charge. This young pedigree bull arrived in the beginning of March 1921 and was handed over to the dairy at Pusa for breeding purposes.

(3) At the request of the Principal, Agricultural College, Cawnpore, a scheme for the establishment of a college dairy dealing with 100 cows together with specifications of buildings, plant, machinery, fixtures, with a note on capital and expenditure, list of live stock and establishment, and plan of building was submitted.

(4) The Director, Department of Industries and Commerce, Hyderabad State (Deccan), asked for a list of plant and machinery with prices necessary to treat milk to be sterilized and cooled when sold as milk from a herd of about 500 animals and also for manufacture of butter and cream. The necessary specification of a pasteurizing and refrigerating plant was accordingly submitted.

(5) There were enquiries from the Director of Agriculture, Bengal, in connection with the improvement in breed of cattle of Bengal; from the Manager, Maharajpore Farm, Gwalior Residency, asking for various breeds of cattle for

breeding purposes; from Revd. Graham, St. Andrews' Colonial Homes, Kalimpong, Bengal, asking advice for feeding his cattle; from the Agricultural Adviser to General Nawab Obaidulla Khan, C.S.I., A.D.C., of Bhopal, asking for English bulls and Sindhi or other cows for cattle-breeding work in Bhopal State; from the Director of Agriculture, Bihar and Orissa, for one Australian bull required for the Directors of the Jahanabad Bank, Gaya, for breeding purposes. In each case all possible information and advice was given.

(6) There were also enquiries from Colonel Edwin S. George, Detriot, Michigan, United States of America, asking all about milch buffaloes in India, from the Director of Agriculture, Province of Salerno, regarding rearing of buffaloes, and from M. A. M. Ch. Porter, Pour La Redaction, et L'Administration, 1, Quai-Chanveau, Lyon, for publications dealing with dairying and cow keeping in India. All possible information was given.

(7) I endorse the remarks of Mr. Smith in paragraph 30 of his report, and I think it is now admitted on every hand that the development of the dairy industry is of paramount importance to this country, and the advice sought from this office from the various Indian States and the general public as enumerated in this report may be taken as a sure indication that the dairy industry shows distinct and very hopeful signs of revival. In this direction, however, I would also emphasize the necessity of the immediate establishment of training schools so that properly trained dairy managers may be forthcoming to satisfactorily run the concerns. I was recently asked to submit estimates for the establishment of a dairy school at Lucknow, already sanctioned by the Secretary of State. This I have done in detail giving estimates and plan of buildings required, also establishment and recurring expenditure.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Wynne Sayer, B. A.)

I continued in charge of the office of the Secretary, Sugar Bureau, throughout the year under report, and worked as a member of the Indian Sugar Committee up to 7th November, 1920. I also officiated as Imperial Agriculturist from 22nd September, 1920, to 28th February, 1921, and was placed in charge of the current duties of the Imperial Dairy Expert in addition to my own from 6th January to 28th February, 1921. There was no change in the office establishment except that one post of recorder which was vacant for a long time was filled on the 12th August, 1920.

Under the original orders of the Government of India the term of the Bureau was limited to two years. As the question of the Bureau was engaging the attention of the Indian Sugar Committee, the Government of India were moved to extend the term of the Bureau for a period of one year or till such time as definite orders are passed on the recommendation of the Committee, whichever is earlier. This was sanctioned by the Government of India.

The main work of the year consisted in furnishing the Indian Sugar Committee with information on the many and various points required by them, in giving replies to the numerous correspondents who seek the advice of this office on matters connected with the Indian sugar industry, and in developing our relations with the Directors of Agriculture, Directors of Industries, the management of sugar factories in India, and the Directors of Sugar Experiment Stations throughout the world. The Bureau has also been able to give considerable assistance to prospective purchasers of sugar machinery by placing them in touch with sugar machinery manufacturers and arranging for early delivery of the machinery required; and on account of delay in deliveries of machinery, has kept a list of

machinery immediately available in England and America for the convenience of enquirers. A press communiqué was published on the subject in August. The raising of the import duty on foreign sugar from 10 to 15 per cent. *ad valorem* with effect from 1st March, 1921, has had the practical effect of giving protection to the Indian sugar industry, and this has stimulated among capitalists the desire for establishing modern factories in suitable localities for which there is ample room. The Bureau in order to assist the sugar trade in India now publishes every week in "The Indian Trade Journal" statistical notes bearing on the production and consumption of this commodity in the principal sugar-producing countries of the world and the rise and fall in the world's price of sugar.

During the year, Mr. Hall, General Manager of the Honolulu Iron Works, Hawaii, paid a visit to India and after seeing the class of cane grown has arranged to construct and send out for trial by this Bureau a small power driven mill, embodying some novel features. I intend to run tests with this mill next season, and wish to express my gratitude to the Honolulu Iron Works for undertaking this piece of work free of charge.

During the year, Mr. William Hulme, who was formerly Sugar Engineer Expert under the Government of India, visited this country on the invitation of his clients. He is thoroughly conversant with Indian conditions and is consulting engineer for several factories in India already. Arrangements were made by the Bureau whereby owners of sugar factories and prospective purchasers of sugar machinery were able to consult Mr. Hulme and take advantage of his experience and technical knowledge. Mr. William Hulme's office is in Liverpool and he is in touch with all English firms connected with the manufacture of sugar machinery. With his knowledge of conditions under which factories have to work in India, he is in an excellent position to advise regarding the class of machinery required. With regard to the manufacture of sugar machinery in India about which I have received

enquiries, I may here say that I do not consider that this will be practicable in the near future. Simpler parts of a sugar factory equipment such as pipes, pans, etc., can be made, and a beginning is being made in this direction which will be a great advantage, as these parts although of simpler construction cost proportionately more in freight on account of their weight and size, but rolls, engines, centrifugals and other equipment entailing special materials and considerable experience in manufacture will have to continue to be imported. As a result of experience gained in the last two years I find the need for a sugar technologist very urgent, but until such an appointment is created the arrangements referred to above will enable me to deal with all enquiries.

Scientific work.

It was stated in last year's report that I brought back some of the latest varieties from Java when I was on tour in that country with the Indian Sugar Committee.

These varieties were E. K. 2, E. K. 28, D. I. 52, S. W. 3, S. W. 111, 66 B, P. O. J. 1410, P. O. J. 1499, and P. O. J. 100, and they were sent to Coimbatore for trial. The last four varieties on examination by the Madras Government Mycologist were suspected to have pine-apple disease. Such healthy sets as he was able to select were sown in big sized pots and kept in quarantine at his pot-culture house for nearly six months before being moved to the Cane-breeding Station. After rejecting unsound material, 46 germinations were obtained. By cutting up the canes when formed, though in unmature condition, it has been possible to multiply this material into 12,000 plants which are now growing at the station. This material is considered adequate to form rough ideas about the characteristics as regards sucrose, etc., of these varieties and their value for crossing purposes at the end of the current season. Speaking tentatively, P. O. J. 1410 and 1499 would appear to be the nearest approaches to the inferior types grown in North India,

and among others there are some which seem likely to be useful even for places which at present grow medium thick or thick canes. P. O. J. 100 was already in India, but I brought this variety over specifically so that there might be no mistake about its identification as has already happened in the case of P. O. J. 36 and 33. This variety has a fairly high sucrose content and matures comparatively early, and as an early maturing cane is one of the principal needs of factories and growers in North India, I anticipate this cane will form a very useful parent for crossing.

In Java they are able to provide sets of a new variety sufficient to plant 4,096 acres at the end of two years from the original area of one acre seed cane by a system of growing the canes to six months and then cutting them for sets and replanting. The sets germinate satisfactorily and form canes within six months, thus enabling one acre of seed cane to provide planting material for 8 acres of new cane which at the end of the next six months give sets for 64 acres which will plant out 4,096 acres at the end of another year of double planting.

As it has been found from trials at Pusa that Coimbatore varieties Co 221, Co 214, Co 213 and Co 210 appear to suit local conditions admirably as regards their yield, sucrose and purity, with the kind assistance of the Imperial Agriculturist I have laid down a plot under these canes according to the Java method for rapid propagation in order to enable me to get sufficient cane for a full day's mill trial next year if possible. The results so far seem promising. It is proposed to extend this line of work in future and to give out sets of these varieties to sugar factories and large cane growers. I am also making arrangements for a mill trial in order to ascertain the behaviour of these canes under true mill conditions which can never be reproduced in laboratory testing. I have also arranged a similar experiment at Dacca which appears to me to be the district corresponding most nearly to Java conditions in this respect.

As the Fiji disease of cane has been spreading in Fiji, Australia, New Guinea and the Philippines, I suggested to the Agricultural Adviser to the Government of India that this disease should be included in the notification issued by the Government of India under the Diseases and Pests Act of 1914 for prohibiting or regulating the import of canes in India. Similar action was also suggested with a view to prevent the introduction of Mosaic disease in this country.

Statistical work.

The question of India's net production and consumption of *gur* (raw uncrystallized sugar) and also of refined sugar is receiving the attention of this Bureau. An enquiry was instituted during the year with a view to ascertain the amount of cane which is put through factories making sugar direct from cane, the quantity of sugar manufactured and molasses turned out. There are 18 factories of this description and the Bureau is indebted to them for the readiness with which they supplied the information required. A note on this subject has been published in " The Indian Trade Journal."

Library.

During the year under report 1,134 volumes were added to the library either by purchase, exchange or free supply. A catalogue of all books and periodicals in the library up to 30th June, 1921, was prepared and is now in the press. Increasing use is being made of the library by students at Pusa, and it has been arranged to supply on loan books to the workers in the provinces, Directors of Industries and others connected with sugarcane cultivation and sugar manufacture in India with reasonable precautions. The library is regularly receiving 42 periodicals bearing on sugar and they are available for reference by those interested. The system of having index cards for all publications received in the library is being maintained.

Museum.

Samples of various grades of sugar manufactured by each factory in India have been obtained and are exhibited in a museum attached to this Bureau. It is proposed to make the museum thoroughly representative by getting samples of *gur* manufactured in each distinctive cane growing tract and by arranging for samples of sugar refined according to the indigenous process.

Publications.

It has been found that "The Indian Trade Journal" which is published weekly is a very suitable medium for the dissemination of information of a statistical and general nature relating to sugar. A few notes were at first contributed to this journal with the result that they brought in a considerable number of enquiries for further information. Accordingly with a view to anticipate such enquiries and to keep the correspondence work of the Bureau within reasonable limits, the practice of contributing such notes every week to this journal has been continued. In all 42 notes were published during the year, and that these are proving useful to the Indian business world is evident from the way in which the firms follow up these notes for further information.

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CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET